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32-bit	Up to 512 Kbytes	64 - 100	Device, Embedded Host, Dual Role, OTG

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VOL. 37. No.9 September 2008

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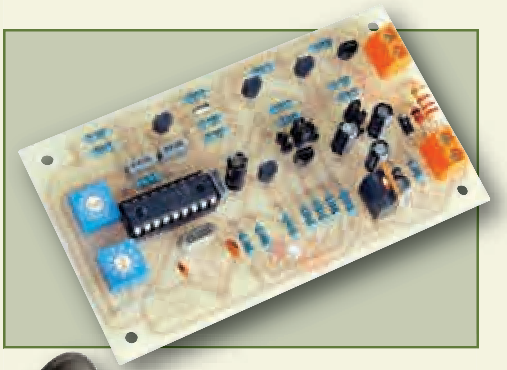

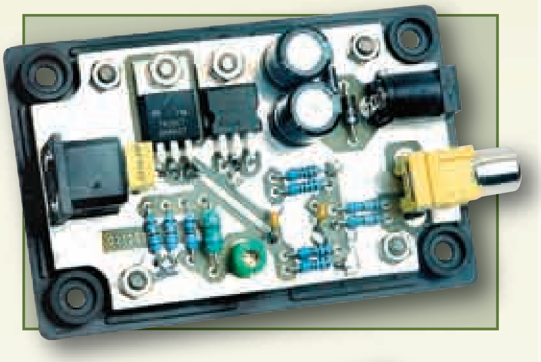

Projects and Circuits

Series and Features

Regulars and Services

Our October 2008 issue will be published on Thursday 11 September 2008, see page 72 for details.

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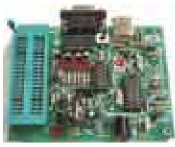
PIC & ATMEL Programmers

We have a wide range of low cost PIC and ATMEL Programmers. Complete range and documentation available from our web site.

Programmer Accessories:
40-pin Wide ZIF socket (ZIF40W) £14.95
18Vdc Power supply (PSU010) £18.95
Leads: Parallel (LDC136) £3.95 / Serial (LDC441) £3.95 / USB (LDC644) £2.95

NEW! USB & Serial Port PIC Programmer



USB/Serial connection. Header cable for ICSP. Free Windows XP software. See website for PICs supported. ZIF Socket and USB lead extra. 18Vdc.
Kit Order Code: 3149KT - **£39.95**
Assembled Order Code: AS3149 - **£49.95**

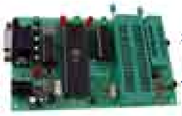
NEW! USB 'All-Flash' PIC Programmer

USB PIC programmer for all 'Flash' devices. No external power supply making it truly portable. Supplied with box and Windows XP Software. ZIF Socket and USB lead not incl.
Assembled Order Code: AS3128 - **£44.95**
Assembled with ZIF socket Order Code: AS3128ZIF - **£59.95**

'PICALL' ISP PIC Programmer

Will program virtually all 8 to 40 pin *serial-mode* AND *parallel-mode* (PIC15C family) PIC microcontrollers. Free Windows software. Blank chip auto detect for super fast bulk programming. Optional ZIF socket.
Assembled Order Code: AS3117 - **£24.95**
Assembled with ZIF socket Order Code: AS3117ZIF - **£39.95**

ATMEL 89xxxx Programmer



Uses serial port and any standard terminal comms program. 4 LED's display the status. ZIF sockets not included. Supply: 16Vdc.
Kit Order Code: 3123KT - **£24.95**
Assembled Order Code: AS3123 - **£34.95**

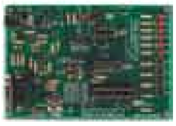
Introduction to PIC Programming

Go from complete beginner to burning a PIC and writing code in no time! Includes 49 page step-by-step PDF Tutorial Manual, Programming Hardware (with LED test section), Win 3.11—XP Programming Software (Program, Read, Verify & Erase), and 1rewritable PIC16F84A that you can use with different code (4 detailed examples provided for you to learn from). PC parallel port.
Kit Order Code: 3081KT - **£16.95**
Assembled Order Code: AS3081 - **£24.95**

PIC Programmer Board

Low cost PIC programmer board supporting a wide range of Microchip® PIC™ microcontrollers. Requires PC serial port. Windows interface supplied.
Kit Order Code: VK8076KT - **£21.95**

PIC Programmer & Experimenter Board



The PIC Programmer & Experimenter Board with test buttons and LED indicators to carry out educational experiments, such as the supplied programming examples. Includes a 16F627 Flash Microcontroller that can be reprogrammed up to 1000 times for experimenting at will. Software to compile and program your source code is included.
Kit Order Code: VK8048KT - **£22.95**
Assembled Order Code: VVM111 - **£39.95**

Controllers & Loggers

Here are just a few of the controller and data acquisition and control units we have. See website for full details. 12Vdc PSU for all units: Order Code PSU445 £8.95

USB Experiment Interface Board

5 digital input channels and 8 digital output channels plus two analogue inputs and two analogue outputs with 8 bit resolution.
Kit Order Code: VK8055KT - **£20.95**
Assembled Order Code: VVM110 - **£39.95**

Rolling Code 4-Channel UHF Remote

State-of-the-Art. High security. 4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 Tx's can be learnt by one Rx (kit includes one Tx but more available separately). 4 indicator LED 's. Rx: PCB 77x85mm, 12Vdc/6mA (standby). Two *& Ten Channel versions also available.*
Kit Order Code: 3180KT - **£44.95**
Assembled Order Code: AS3180 - **£54.95**

Computer Temperature Data Logger

Serial port 4-channel temperature logger. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 45x45mm. Powered by PC. Includes one DS1820 sensor.
Kit Order Code: 3145KT - **£17.95**
Assembled Order Code: AS3145 - **£24.95**
Additional DS1820 Sensors - **£3.95 each**

Most items are available in kit form (KT suffix) or pre-assembled and ready for use (AS prefix).

4-Ch DTMF Telephone Relay Switcher

Call your phone number using a DTMF phone from anywhere in the world and remotely turn on/off any of the 4 relays as desired. User settable Security Password, Anti-Tamper, Rings to Answer, Auto Hang-up and Lockout. Includes plastic case. 130 x 110 x 30mm. Power: 12Vdc.
Kit Order Code: 3140KT - **£54.95**
Assembled Order Code: AS3140 - **£69.95**

8-Ch Serial Port Isolated I/O Relay Module

Computer controlled 8 channel relay board. 5A mains rated relay outputs and 4 opto-isolated digital inputs (for monitoring switch states, etc). Useful in a variety of control and sensing applications. Programmed via serial port (use our new Windows interface, terminal emulator or batch files). Serial cable can be up to 35m long. Includes plastic case 130x100x30mm. Power: 12Vdc/500mA.
Kit Order Code: 3108KT - **£54.95**
Assembled Order Code: AS3108 - **£64.95**

Infrared RC 12–Channel Relay Board

Control 12 onboard relays with included infrared remote control unit. Toggle or momentary. 15m+ range. 112 x 122mm. Supply: 12Vdc/0.5A
Kit Order Code: 3142KT - **£47.95**
Assembled Order Code: AS3142 - **£59.95**

Audio DTMF Decoder and Display

Detect DTMF tones from tape recorders, receivers, two-way radios, etc using the built-in mic *or* direct from the phone line. Characters are displayed on a 16 character display as they are received and up to 32 numbers can be displayed by scrolling the display. All data written to the LCD is also sent to a serial output for connection to a computer. Supply: 9-12V DC (Order Code PSU445). Main PCB: 55x95mm.
Kit Order Code: 3153KT - **£24.95**
Assembled Order Code: AS3153 - **£34.95**

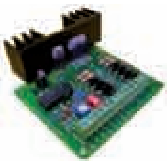
Telephone Call Logger

Stores over 2,500 x 11 digit DTMF numbers with time and date. Records all buttons pressed during a call. No need for any connection to computer during operation but logged data can be downloaded into a PC via a serial port and saved to disk. Includes a plastic case 130x100x30mm. Supply: 9-12V DC (Order Code PSU445).
Kit Order Code: 3164KT - **£54.95**
Assembled Order Code: AS3164 - **£69.95**

Hot New Products!

Here are a few of the most recent products added to our range. See website or join our email Newsletter for all the latest news.

Bipolar Stepper Motor Chopper Driver



New bipolar chopper driver gives better performance from your stepper motors. It uses a dual full bridge motor driver based on SGS Thompson chips L297 & L298. Motor current for each phase is set using an on-board potentiometer. Can handle motor winding currents of up to 2 Amps per phase. Operates from a DC supply voltage of 9-36V. All basic motor controls provided including full or half stepping of bipolar steppers and direction control. Synchroniseable when using multiple drivers. Perfect for desktop CNC applications.
Kit Order Code: 3187KT - **£29.95**
Assembled Order Code: AS3187 - **£39.95**

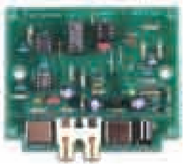
Shaking Dice

This electronic construction kit is great fun to build and play with. Simply shake and watch it slowly roll to stop on a random number.
Kit Order Code: VMK150KT - **£9.95**

Running MicroBug

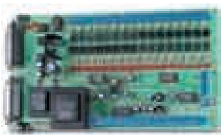
This electronic construction kit is an attractive bright coloured bug-shaped miniature robot. The microbug is always hungry for light and travels toward it!
Kit Order Code: VMK127KT - **£9.95**

Video Signal Cleaner



Digitally cleans the video signal and removes unwanted distortion in video signal. In addition it stabilises picture quality and luminance fluctuations. You will also benefit from improved picture quality on LCD monitors or projectors.
Kit Order Code: VK8036KT - **£19.95**
Assembled Order Code: VVM106 - **£26.95**

PC Interface Board



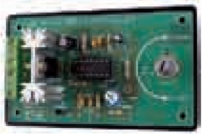
This interface card excels in its simplicity of use and installation. The card is connected in a very simple way to the printer port (there is no need to open up the computer). Likewise there is no need to install an extra printer port, even if a printer is to be used. This can be connected to the card in the usual manner. Connection to the computer is optically isolated, so that damage to the computer from the card is not possible.
Kit Order Code: VK8000KT - **£59.95**

Most items are available in kit form (KT suffix) or assembled and ready for use (AS prefix).

Motor Speed Controllers

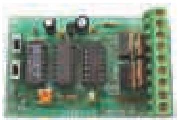
Here are just a few of our controller and driver modules for AC, DC, Unipolar/Bipolar stepper motors and servo motors. See website for full details.

DC Motor Speed Controller (100V/7.5A)



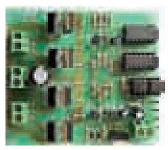
Control the speed of almost any common DC motor rated up to 100V/7.5A. Pulse width modulation output for maximum motor torque at all speeds. Supply: 5-15Vdc. Box supplied. Dimensions (mm): 60Wx100Lx60H.
Kit Order Code: 3067KT - **£13.95**
Assembled Order Code: AS3067 - **£21.95**

PC / Standalone Unipolar Stepper Motor Driver



Drives any 5, 6 or 8-lead unipolar stepper motor rated up to 6 Amps max. Provides speed and direction control. Operates in stand-alone or PC-controlled mode. Up to six 3179 driver boards can be connected to a single parallel port. Supply: 9Vdc. PCB: 80x50mm.
Kit Order Code: 3179KT - **£12.95**
Assembled Order Code: AS3179 - **£19.95**

Bi-Polar Stepper Motor Driver



Drive any bi-polar stepper motor using externally supplied 5V levels for stepping and direction control. These usually come from software running on a computer. Supply: 8-30Vdc. PCB: 75x85mm.
Kit Order Code: 3158KT - **£17.95**
Assembled Order Code: AS3158 - **£27.95**

Bidirectional DC Motor Controller

Controls the speed of most common DC motors (rated up to 32Vdc/10A) in both the forward and reverse direction. The range of control is from fully OFF to fully ON in both directions. The direction and speed are controlled using a single potentiometer. Screw terminal block for connections.
Kit Order Code: 3166v2KT - **£17.95**
Assembled Order Code: AS3166v2 - **£27.95**

AC Motor Speed Controller (700W)

Reliable and simple to install project that allows you to adjust the speed of an electric drill or single phase 230V AC motor rated up to 700 Watts. Simply turn the potentiometer to adjust the motors RPM. PCB: 48x65mm. Not suitable for use with brushless AC motors.
Kit Order Code: 1074KT - £12.95
Assembled Order Code: AS1074—£18.95
Box Order Code 2074BX - £5.95

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Order Code EPL500 - **£149.95**
Also available - 30-in-1 **£16.95**, 50-in-1 **£21.95**, 75-in-1 **£32.95** £130-in-1 **£39.95** & 300-in-1 **£59.95** (details on website)

Tools & Test Equipment

We stock an extensive range of soldering tools, test equipment, power supplies, inverters & much more - please visit website to see our full range of products.

Two-Channel USB Pc Oscilloscope

This digital storage oscilloscope uses the power of your PC to visualize electrical signals. Its high sensitive display resolution, down to 0.15mV, combined with a high bandwidth and a sampling frequency of up to 1GHz are giving this unit all the power you need.
Order Code: VPCSU1000 - **£289.95**

Personal Scope 10MS/s

The Personal Scope is not a graphical multimeter but a complete portable oscilloscope at the size and the cost of a good multimeter. Its high sensitivity - down to 0.1mV/div - and extended scope functions make this unit ideal for hobby, service, automotive and development purposes. Because of its exceptional value for money, the Personal-Scope is well suited for educational use.
Order Code: VHPS10 - ~~£129.95~~ **£119.95**

See website for more super deals!

No.1 FOR KITS

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EVERYDAY PRACTICAL ELECTRONICS

FEATURED KITS

September '08

Everyday Practical Electronics Magazine has been publishing a series of popular kits by the acclaimed Silicon Chip Magazine Australia. These projects are 'bullet proof' and already tested down under. All Jaycar kits are supplied with specified board components, quality fibreglass tinned PCBs and have clear English instructions. Watch this space for future featured kits.

Jaycar Electronics

GALACTIC VOICE SIMULATOR KIT

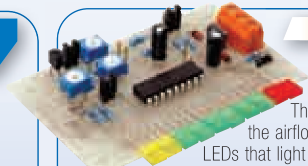
NEW FOR 08

KC-5431 £13.25 plus postage & packing

This galactic voice simulator kit has effect and depth controls to allow you to vary the effect to simulate everything from the metallically-challenged C-3PO, to the hysterical ranting of Daleks. The kit includes PCB with overlay, enclosure, speaker panel and all components.

- Requires 9V battery.
- As published in EPE Magazine August 2008

VOLTAGE MONITOR KIT



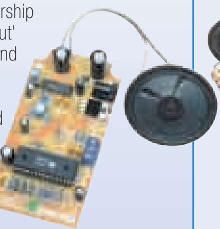
KC-5424 £6.00 plus postage & packing

This versatile kit will allow you to monitor the battery voltage, the airflow meter or oxygen sensor in your car. The kit features 10 LEDs that light in response to the measured voltage, preset 9-16V, 0-5V or 0-1V ranges, complete with a fast response time, high input impedance and auto dimming for night driving. Kit includes PCB with overlay, LEDs and all electronic components with clear English instructions.

- Requires 12VDC power • Recommended box: UB5 HB-6015 £0.83
- As published in EPE Magazine November 2007.

STARSHIP DOOR SOUND EMULATOR

KC-5423 £11.75 plus postage & packing



This easy to build kit emulates the unique noise made when the cabin doors on the Starship Enterprise open & close. The 'shut' noise is also duplicated. The sound emulator can be triggered by switch contacts (normally open) which means you can use a reed magnet switch, IR beam or PIR detector to trigger the unit.

- Requires 9-12VDC power
- Kit supplied with PCB & all electronic components
- As published in EPE Magazine June 2008

3V TO 9V DC TO DC CONVERTER KIT

KC-5391 £4.95 plus postage & packing

Allows you to use regular Ni-Cd or Ni-MH 1.2V cells, or alkaline 1.5V cells for 9V applications. Using low cost, high capacity rechargeable cells, this kit will pay for itself in no time. You can use any 1.2-1.5V cells you desire. Imagine the extra capacity you would have using two 9000mAh D cells in replacement of a low capacity 9V cell.

- Kit supplied with PCB & all electronic components.
- As published in EPE Magazine June 2007

INTERCOOLER WATER SPRAY CONTROLLER

KC-5422 £3.00 plus postage & packing

Intercooler water sprays are a very effective and inexpensive way of upgrading intercooler performance. Using a 'dump' system to trigger the spray often results in the need for frequent water top-ups. Simply add these few components to the Smart Fuel Mixture Display Kit (KC-5374) and reduce water consumption by up to two-thirds with no loss in cooling efficiency.

- Kit supplied with PCB & all electronic components
- As published in EPE Magazine March 2008

THE FLEXITIMER KIT

KA-1732 £5.95 plus post & packing

This kit uses a handful of components to accurately time intervals from a few seconds to a whole day. It can switch a number of different output devices and can be powered by a battery or mains plugpack. The kit includes PCB and all components. Requires 12-15VDC wall adaptor.

- As published in EPE Magazine September 2007.

AUDIO VIDEO BOOSTER KIT

KC-5350 £31.95 plus post & packing

This kit will boost your video and audio signals preserving them for the highest quality transmission to your projector or large screen TV. It boosts composite, S-Video, and stereo audio signals. Kit includes case with silkscreened and punched panels, PCB and all electronic components.

- As published in EPE Magazine March 2006

STUDIO 350 HIGH POWER AMP KIT

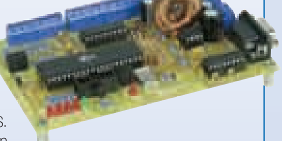
KC-5372 £55.95 plus post & packing

It delivers a whopping 350WRMS into 4 ohms, or 200WRMS into 8 ohms. Using eight 250V 200W plastic power transistors, it is super quiet, with a signal to noise ratio of -125dB(A) at full 8 ohm power. Harmonic distortion is just 0.002%, & frequency response is almost flat (less than -1dB) between 15Hz and 60kHz.

- Kit supplied in short form with PCB and electronic components.
- Kit requires heatsink and +/- 70V power supply (a suitable supply is described in the instructions).
- As published in EPE Magazine October & November 2006

SMS CONTROLLER MODULE

KC-5400 £15.95 + postage & packing

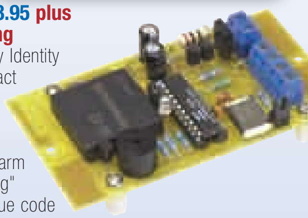


Control appliances or receive alert notification from anywhere. By sending plain text messages this kit will allow you to control up to 8 devices. At the same time, it can also monitor four digital inputs. It works with old Nokia handsets such as the 5110, 6110, 3210, and 3310, which can be bought inexpensively if you do not already own one. Kit supplied with PCB, pre-programmed microcontroller and all electronics components with clear English instructions.

- Requires a Nokia data cable which can be readily found in mobile phone accessory stores.
- As published in EPE Magazine March 2007

RFID SECURITY MODULE RECEIVER KIT

KC-5393 £28.95 plus post & packing



Radio Frequency Identity (RFID) is a contact free method of controlling an event such as a door strike or alarm etc. An "RFID Tag" transmits a unique code when energised by the receiver's magnetic field. As long as a pre-programmed tag is recognised by the receiver, access is granted. This module provides normally open and normally closed relay contacts for flexibility. It works with all EM-4001 compliant RFID tags. Kit supplied with PCB, tag, and all electronic components.

- As published in EPE Magazine August 2007

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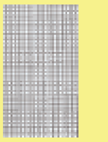
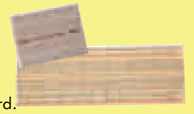
95 × 432mm	36T / 170H	£4.39
100 × 100mm	39T / 38H	£1.40
100 × 500mm	39T / 199H	£7.50
119 × 455mm	46T / 179H	£5.40
Stripboard track cutter		£1.99



Solderless Breadboard

Tie Points & Size		Power Rails	
390	81 x 60mm	2	£2.75
840	175 x 67mm	2	£4.86
740	175 x 55mm	1	£3.32
640	175 x 42mm	0	£3.08

Many other sizes available, also jump wires & matrix board.



PCB Production - Drafting Materials
A4 Artwork Film (per 10 sheets)
Clear Manual Film £1.20
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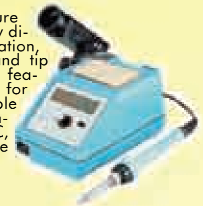
Antex Pro 210mm £11.11

Soldering Station
A 48W adjustable temperature soldering station with a rotary dial, LED Temperature metering, on-off switch, iron holder and tip cleaning sponge. This station features accurate heat sensing for instant compensation & stable temperatures. Adjustable temperature range of 150 - 420°C, Low voltage iron with Silicone cable.
Supply: 240V, Iron: 24V 48W

Model 167-540 £49.00

Soldering Station
A 48W adjustable temperature soldering station with a rotary dial, Digital Temperature Indication, on-off switch, iron holder and tip cleaning sponge. This station features accurate heat sensing for instant compensation & stable temperatures. Adjustable temperature range of 150 - 480°C, Low voltage iron with Silicone cable.
Supply: 240V, Iron: 24V 48W



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Model: 121-120
Price: £11.47
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Technical Specifications
DC voltage 200mV - 1000V (±0.5%)
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DC current 2mA - 20A (±1.2%)
AC current 200mA - 20A (±1.8%)
Resistance 200 Ohms - 20M Ohms (±0.8%)
Capacitance 2000pF - 20μF (±2.5%)
Temperature 0°C - 1000°C (±1.5%)
Frequency 20kHz (±1%)
Max display 1999
Power supply 9V (PP3 battery)
Dimensions 88 x 173 x 40 mm

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0-50mA	1Ω2
0-100mA	0Ω65
0-500mA	0Ω12
0-1A	60mΩ
0-3A	20mΩ
0-5A	12mΩ
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±50uA	1k9

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10 x 12"	£8.19	£10.01	£10.78	£11.83
12 x 12"	£8.26	£10.08	£10.99	£12.25
100 x 160mm			£2.38	£2.66
203 x 114mm			£3.01	£3.43
220 x 100mm			£3.08	£3.71
233 x 160mm			£4.83	£5.32
233 x 220mm			£6.86	£7.70

PCB Production - Chemicals

100ml	Aerosol Photoresist spray, covers 2m²	£5.12
50g	Powder developer, makes 1lt	£1.09
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26 Way	£0.26	£13.94
34 Way	£0.34	£18.22
40 Way	£0.40	£21.44
50 Way	£0.50	£26.80
60 Way	£0.64	£33.92
IDC Crimp tool		£10.60

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UTP Cable
Conforms to CAT5E 100MHz standard, ETA verified TIA/EIA 568-B.2

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exc carriage.

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RJ45 Module
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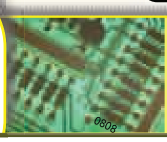

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EVERYDAY PRACTICAL ELECTRONICS EDITORIAL
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Phone: (01202) 873872. Fax: (01202) 874562.
Email: enquiries@epemag.wimborne.co.uk
Web Site: www.epemag.co.uk
EPE Online (downloadable version of EPE): www.epemag.com
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VOL. 37 No. 9 SEPTEMBER 2008

Breadboard Projects

This issue marks the end of the current Teach-In series; it has been a fascinating journey through the world of PICs, and John Becker is to be congratulated for providing such an illuminating and engaging tour – thank you John.

It's a tough act to follow, but I think we've come up with something that will prove just as useful and educational. Starting next month in the October issue, we're launching a 13-part series of breadboard-based projects written by Dr Malcolm Plant. This will be a true learning-for-beginners series, where the emphasis will be on design and making things work, rather than getting caught up in the intricacies of PCBs, soldering and more advanced construction techniques – hence the use of breadboards. The beauty of 'breadboarding' is that if you make a mistake then all you need to do is pull out a wire or component and reposition it – no solder suckers, lifted tracks or cooked ICs to worry about. It's a technique popular with advanced designers as well as new recruits, so you'll be in good company as you start out on your first circuits.

The real appeal of this series though is the quality of the circuits and projects – just because the articles are aimed at beginners does not mean that all you'll do is switch the odd LED on and off – quite the opposite. The projects lined up for the series include: a rain check device, a thermostat, an intercom, a frost alert, a motion detector and even an AM radio and sound meter, so plenty for all you budding circuit builders to get your teeth into.

In a practical hands-on environment such as electronics, 'doing' is far and away the best method of learning. We are sure this series of articles will not only be as popular as the recent Teach-In PIC one, but will also help you get to grips with the fundamentals of electronic design. And, as always, we look forward to your letters and emails describing triumphs and the occasional hiccup!

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Copies of *EPE* are available on subscription anywhere in the world (see opposite) and from all UK newsagents (distributed by SEYMOUR). *EPE* can also be purchased from retail magazine outlets around the world. An Internet online version can be purchased and downloaded for just $18.99US (approx £9.50) per year, available from **www.epemag.com**

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PROJECTS AND CIRCUITS
All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.
A number of projects and circuits published in *EPE* employ voltages that can be lethal. You should not build, test, modify or renovate any item of mains-powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.

COMPONENT SUPPLIES
We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers.
We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

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NEWS

A roundup of the latest Everyday News from the world of electronics

New Sky Decoder

Barry Fox reports that the door is now opening for new devices which let a TV or PC receive encrypted satellite broadcasts from Sky

News broke recently when NDS – the company owned by Rupert Murdoch's News Corporation and developer of the VideoGuard encryption system used by Murdoch's Sky in the UK and DirecTV in the US – held briefings in London.

"There is a lot of work in our labs that may never see the light of day. But some projects are ready to become consumer products in the next two to five years years," Nigel Smith NDS's Chief Marketing Officer and Jonathan Beavon, Director of Segment Marketing, revealed at recent briefings and demonstrations in London.

All existing Sky receivers have a dedicated slot for a VideoGuard smart card. But Sky and NDS have never licensed VideoGuard for use in PCs, TVs or third party set top boxes (STBs) which have a Common Interface slot for a Conditional Access Module. The CAM is like a PCMCIA card for a laptop that has its own smart card slot. The CAM has software onboard which works with the smart card to decrypt the TV signal and send it back into the TV or STB or PC. "We don't believe in the European Common Interface" says Smith. "The content can be taken when it comes out of the module. In the US, the PCMCIA solution used is more secure."

NDS has recently worked with SanDisk on SD memory cards that carry and play encrypted audio and video. Now, NDS will launch its own solution; the VideoGuard PC Key is a USB stick which lets a PC receive encrypted TV broadcasts, for display on the PC screen or a TV, and transfer the programme to a personal media player for portable play. A conventional STB connects to a PC by USB ports, while a USB stick, with an in-built smart card system, works with DRM software on the PC to de-encrypt the programme.

Portable play

The signal can be reformatted for portable play and transmitted by WiFi or hard-wire, with encryption, to a phone or personal media player. Connection can be automatic, with the STB sending the PMP any programmes that have been recorded by the DVR but not yet watched. Programme transfers can be made as rental or electronic gifts. The USB key can also store the programme for physical transfer.

The encryption process must change each time it is used because PC architecture is open to hackers. "We are talking seriously to two operators in the US and two in Europe about a service launch at the beginning of next year. Sky has seen it", says Smith guardedly.

NDS thinks that with around one third of pay TV subscribers now using digital video recorders, the time is right to introduce targeted adverts. A broadcaster, such as Sky or DirecTV, can 'push' a library of 30 second adverting slots into a subscribers' DVR so that the DVR can replace off-air adverts with sales pitches of more interest to the individual viewer. The same system can take adverts from the Internet and reformat them for TV display. "People will start liking adverts again" says Smith hopefully.

Time-out

Smith and Beavon acknowledge that DRM and encryption can be bypassed and defeated simply by copying the analogue output from a STB. "But the analogue hole is getting smaller," says Smith. "Like the ozone layer, it's disappearing. The use of HDMI and HDCP is making it harder to copy.

Time for analogue is running out, and analogue copying has to be done in real time. With a lot of material to copy it's just not viable for most people. Lack of bandwidth has been holding things back. But that's changing too."

NDS leaves no doubt it is gunning for Apple. "iTunes dominates the music market. But it is not the same for video, where there is so much material continually being originated. Apple does not yet have any anything like the width of video content it has for music. There is an opportunity for the operators to use a different system for video – if they strike early enough. If they don't, the market goes to iTunes or the Internet."

CIRCUIT SPECIALISTS ARRIVE

Circuit Specialists was founded in the US in 1971 (**www.circuitspecialists.com**). Over the last 37 years the company has grown into one of the largest distributors of electronic equipment and supplies in the US, having built a reputation for quality and customer care along the way. Products are sourced for their reliability and value for money.

Products that have formed Circuit Specialists' core business over recent years are now available to customers in the EU. You can buy at the same competitive prices without the shipping costs and the customs issues normally associated with importing from the US.

Based in Manchester, England, Circuit Specialists Europe (**www.circuitspecialists.co.uk** or **www.circuitspecialists.eu**), specialise in providing a quality range of products aimed at the hobbyist, the designer and the small commercial enterprise.

The company stock a select range of soldering and desoldering stations, and a wide range of associated accessories. Own-brand bench power supplies are manufactured for the company, enabling them to be very competitively priced. A long-standing relationship with Chinese company Heng Fu ensures the supply of a range of enclosed switching power supplies, which are extremely reliable and offer excellent value for money.

Take a look at **www.circuitspecialists.co.uk** where, as we go to press, there is 10% off everything' in the Mid-season Sale. See their advert on page 71.

WIRE-FREE POWER

WildCharge Inc has announced the release to the general public of its adapters that WildCharge-enable Apple iPhone, iPod touch and Blackberry Pearl and 8800. The company's WildCharger wire-free charging pad, winner of this year's *CES* Best of Innovations Award, portable power category, is a sleek, flat charging pad that delivers up to 15 Watts of power, capable of simultaneously charging up to four small devices, such as cellular phones, portable music players, digital cameras, and other similar electronic devices.

"WildCharge's technology is more than a simple charging solution for mobile devices – it's a true revolution that will ultimately eliminate the array of tangled chargers, adapters and cords consumers currently deal with on a regular basis," claimed WildCharge CEO Dennis Grant, while displaying WildCharge's device adapter for Apple's iPhone.

For more information browse **www.wildcharge.com**.

FREE LINUX DRIVER

The new Linux driver from Pico Labs allows programmers to control the PicoScape 2000 Series and PicoScope 3000 Series scopes using their own software. Linux programmers can now have access to Pico's full range of entry-level and general-purpose oscilloscopes.

Anybody with a PC and a spare USB port can download and use the driver free of charge and with no licensing restrictions. The driver is supplied as an RPM package that has been tested with Fedora 8, Ubuntu 8.04 and openSUSE 10.4, and is accompanied by example programs in C and full instructions.

As Alan Tong, Managing Director of Pico Technology, explained, "Linux is widely used in the embedded computing, medical and scientific fields because it is stable, open-source and easy to modify, and can run a wide variety of applications. Now these users can choose any scope from our 2000 and 3000 Series scopes to integrate into their own applications."

The driver is available from the Pico website at **www.picotech.com**. For more information, Pico can be contacted at Pico Technology, James House, Colmworth Business Park, Eaton Socon, St. Neots, Cambridgeshire PE19 8YP. Tel: +44 (0) 1480 396 395 Fax: +44 (0) 1480 39629.

MERG Journal

The Model Electronic Railway Group (MERG) have sent us their Summer 2008 journal. As usual it has news of the Group's activities along with useful constructional articles.

MERG hold meetings in London five times a year. The venue is the Model Railway Club, Calshot Street N1 9DA, very near King's Cross Station. The next meeting is on 13 September, when one of their members will give a detailed illustrated talk on a relatively simple and cost effective bus for controlling model railways. Non-members are welcome.

*For more information, contact MERG, Spread Eagles, Melbury Abbas, Dorset SP7 0DU, or browse **www.merg.info**.*

PHONE THEFT PROTECTION

Modern phones store as much personal data as a PC, but are much more easily lost or stolen. Password protection does not help if the phone was 'open' when taken. IT and Internet security company Kaspersky has developed a low-cost application which sits on a phone and protects it against unauthorised use.

Kaspersky Mobile Security 7.0 costs £14 and works on smartphones running Windows Mobile 5.0 or 6.0 and Symbian Ver 9 operating systems. While the phone is with its rightful owner, the software routinely scans incoming files and accessed web sites, checking for viruses. If the phone goes missing the owner can send it a text which either temporarily blocks its use or permanently erases all data stored inside the phone.

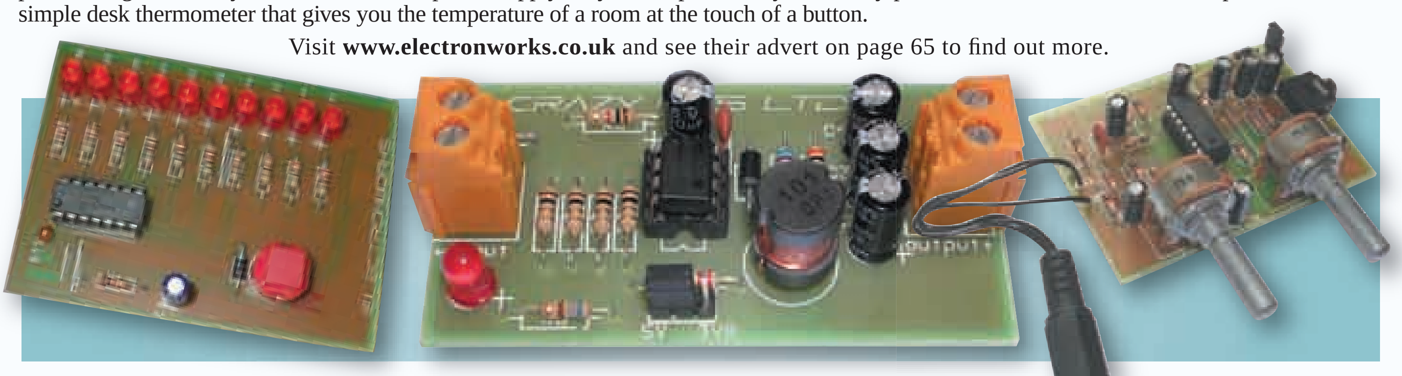
If the thief tries to use the phone with a different SIM card, the phone sends a text message to a pre-arranged number, giving the number of the new SIM. So the rightful owner can send a text message to disable it. **Barry Fox**

Electronworks Kits

Electronworks comment that they've taken some of life's insanity (and lots of their own) and put it into their electronic kits. The aim is to make learning electronics fun and to bring you a range of kits that are both practical and educational.

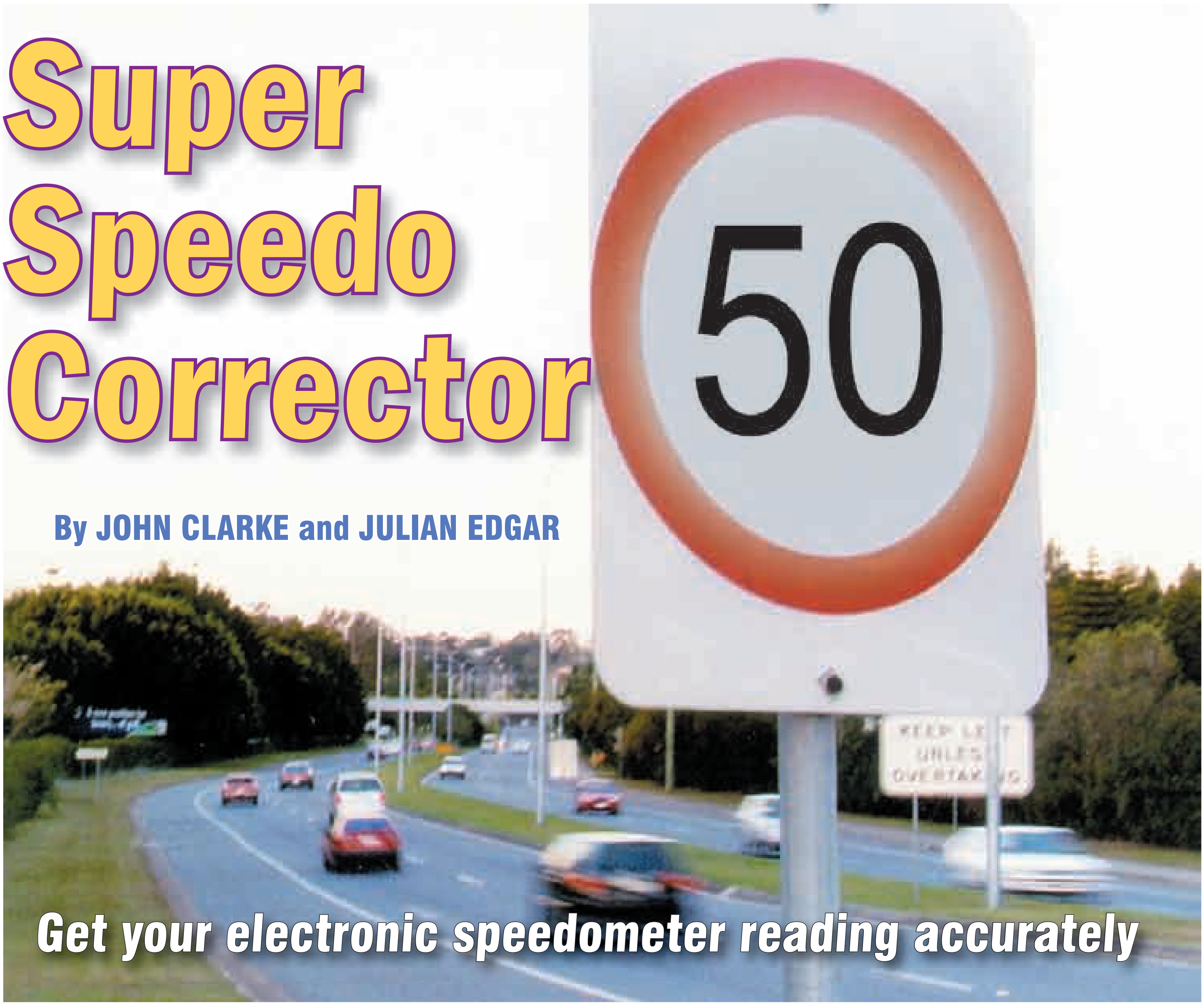
They have a whole ton of kits and ideas that they will be unleashing on you in the coming months, so if you are young or old, new to electronics or a seasoned veteran, you will find something to suit your needs. For example, they have an MP3 booster that amplifies the output of your MP3 player, so you can fill the room with music via your PC speakers. They have an electronic coffee mat that lights up a sequence of LEDs when you place a mug on it. They also have an in-car power supply, so you can power all your battery powered electronics from a 12V input and there's a simple desk thermometer that gives you the temperature of a room at the touch of a button.

Visit **www.electronworks.co.uk** and see their advert on page 65 to find out more.



Super Speedo Corrector

By JOHN CLARKE and JULIAN EDGAR



Get your electronic speedometer reading accurately

THESE DAYS, having an accurate car speedometer is vital if you're to avoid fines and collecting licence points. But how do you correct the speedometer if it is reading high or low? It's easy with the Super Speedo Corrector, which will work with any electronic speedometer – digital or analogue. It allows you to alter the reading in 1% increments, either up or down.

Before you can use the Speedo Corrector, you'll have to find and identify the speedometer sensor output wire or the speed signal output wire from the ECU. In some cars that's easier said than done, so make sure you have a car wiring diagram and that you can physically access the speedometer input wire, which is normally at the back of the instrument cluster. If you can't find the right wire, you won't be able to install the Speedo Corrector.

This project includes an automatic set-up procedure, whereby the Super Speedo Corrector calibrates itself to suit the speed signal output characteristics; an on-board status LED flashes to show correct operation; and an AC output signal that will work with Nissan speedometers.

Speedo Corrector: main uses

- Correct inaccurate speedometers in standard cars
- Correct inaccurate speedometer caused by changed differential or gearbox ratios.
- Correct inaccurate speedometer caused by changed tyre diameters.
- Correct tachometers

Circuit description

The circuit (Fig.1) is based on microcontroller IC1, which is programmed to alter an incoming frequency by a set amount. The exact amount is set using two BCD rotary switches (S1, S2), which alter the frequency in 1% steps.

The speedometer signal is applied to the input of the circuit that has the options of a 1kΩ pull-up resistor

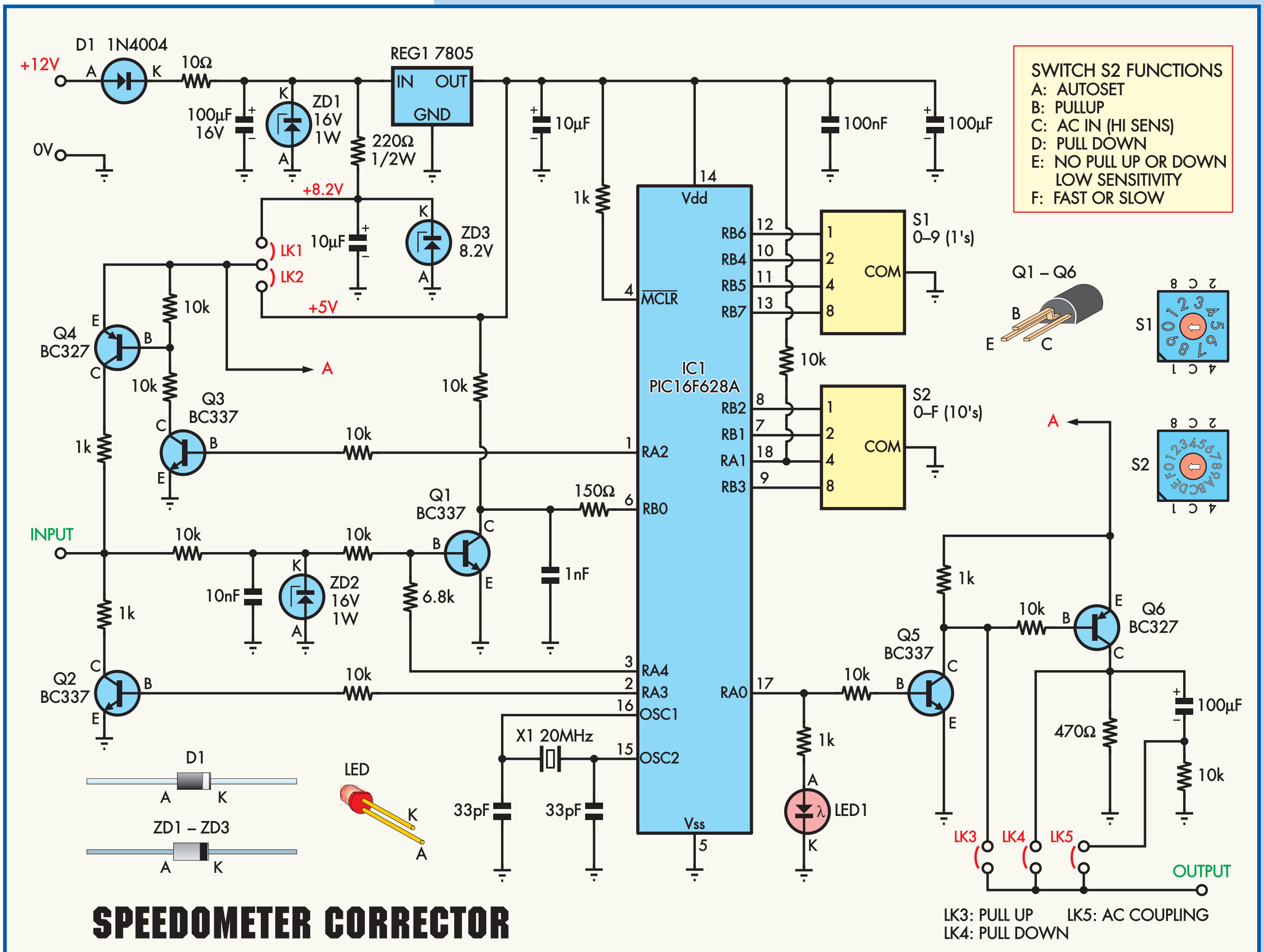
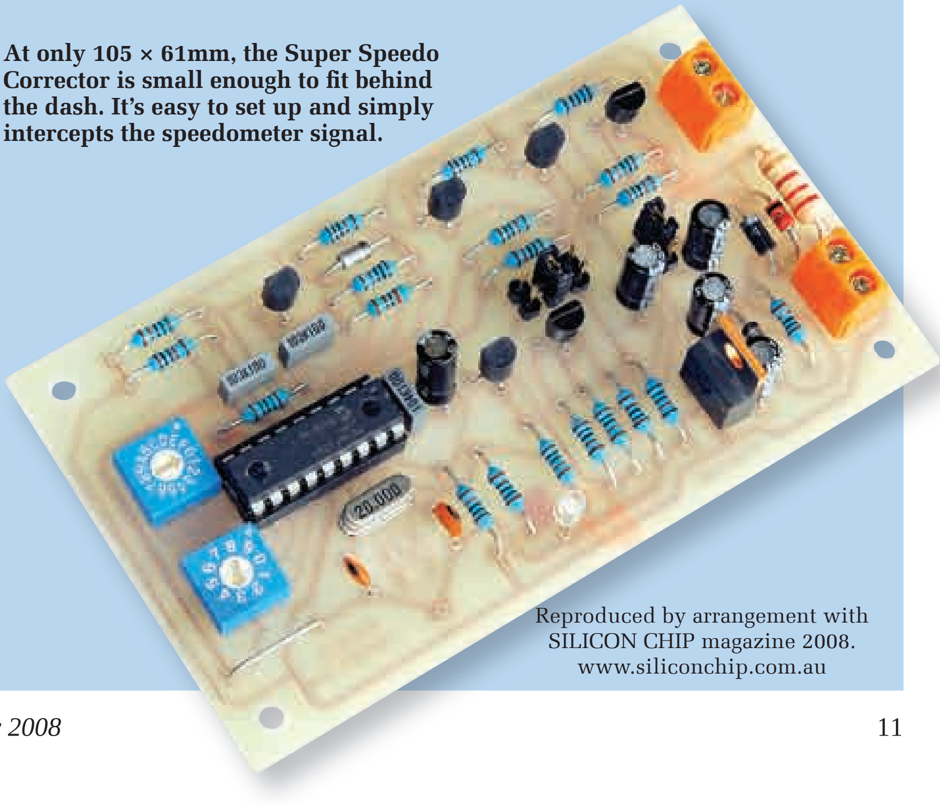


Fig.1: all the clever stuff in this circuit is done by PIC microcontroller IC1. It takes the speedometer signal and multiplies it by a factor set by two rotary BCD switches (S1 and S2). The speedometer signal frequency can be either increased or decreased in 1% increments – see text.

selected with transistor Q4 or a 1kΩ pull-down resistor selected with transistor Q2. By selecting either link LK1 or LK2, the pull-up resistor can be connected to either the +8.2V supply or the +5V supply.

The input signal is then fed via a 10kΩ resistor to Zener diode ZD2, which ensures that levels cannot go above +16V or below –0.6V. A parallel 10nF capacitor filters the signal, which then drives transistor Q1 via a voltage divider consisting of 10kΩ and 6.8kΩ resistors.

The 6.8kΩ resistor, at the base of Q1, can be either connected to ground via the RA4 output of IC1, or left floating when the RA4 output is set as a high-impedance input. When the resistor is connected to ground, the signal level required to switch Q1 is about 2.5V. Alternatively, when this



At only 105 × 61mm, the Super Speedo Corrector is small enough to fit behind the dash. It's easy to set up and simply intercepts the speedometer signal.

Features and Specification

Main features

- Allows alteration of speedometer reading so it reads faster or slower
- Automatic or manual set-up of input signal detection
- Caters for three output signal types
- LED indication of valid speed sensor signal being received
- LED indication of output operation

Specification

- Output rate – adjustable in 1% steps from 0 to 99%
- Output – either faster or slower than the input rate
- Input and output types – pull-up or pull-down resistance, or AC
- Output swing – 0 to 8.2V or 0 to 5V or 8.2V peak-to-peak AC or 5V peak-to-peak AC
- Minimum operating frequency – adjustable from 1Hz to 16Hz
- Maximum input frequency to maintain 1% change resolution: 1.2kHz
- Maximum input voltage: 50V RMS
- Minimum input sensitivity: 0.7V peak (on high sensitivity setting)
- Minimum input sensitivity: 2.5V peak (on low sensitivity setting)
- Power: 9V to 15V at 25mA

resistor is effectively out of circuit, the sensitivity is lowered to around 0.7V peak.

The RA2 output of IC1 is used to select the pull-up resistor. When RA2's output is at 5V, it switches on transistor Q3 and this in turn switches on transistor Q4. Q4 then connects the 1kΩ pull-up resistor from the input to Q4's collector, which then connects the pull-up resistor to the +8.2V or +5V supply rail. If RA2 is at 0V, transistors Q3 and Q4 are off and there is no pull-up resistor in circuit.

The RA3 output selects the pull-down resistor when its output is at 5V. This output drives transistor Q2 to connect the 1kΩ resistor at its collector to ground. When RA3 is at 0V, the pull-down resistor is out of circuit.

Transistor Q1's collector inverts the signal and drives pin 6 (RB0) of IC1 via a 10kΩ pull-up resistor and a 150Ω series resistor. A 1nF capacitor filters out any high-frequency voltage variations. Pin 6 includes an internal Schmitt trigger to ensure a clean signal for measurement.

The rotary BCD switches (S1 and S2) are monitored via the RB1 to RB7 inputs and the RA1 input. The RB inputs are normally held high via internal pull-up resistors within IC1, while the RA1 input uses a 10kΩ resistor to ensure that its input is held high, unless pulled low via switch S2.

The switches provide a unique BCD (binary coded decimal) value on these inputs for each setting.

Output signal

The output signal is at RA0 (pin 17). This drives the indicating LED (LED1) via a 1kΩ resistor and the base of transistor Q5. Q5's collector is held high via a 1kΩ resistor, which connects to either the +8.2V or +5V supply (via link LK1 or LK2).

Transistor Q5's collector provides the pull-up output signal and also drives Q6, which has a pull-down resistor at its collector to provide the pull-down output. Coupling the pull-down output via a 100µF capacitor provides an AC output. The 10kΩ resistor provides the discharge path, while links LK3, LK4 and LK5 select the pull-up, pull-down and AC outputs, respectively.

An internal power-on reset for IC1 is provided using the $\overline{\text{MCLR}}$ input (pin 4) which is connected to the 5V supply via a 1kΩ resistor. This keeps the IC reset until the power supply voltage is correct.

IC1 operates at 20MHz using crystal X1. This frequency was chosen so that the software program runs sufficiently fast to operate with speedometer signals up to 1.2kHz. Note that the Super Speedo Corrector will operate with speedometer signals above these frequencies, however the accuracy of speedometer correction will be reduced.

Mechanical speedo?

The Super Speedo Corrector will work only on electronic speedometers – ie, those that don't have a mechanical rotating cable driving them. If you have an older car with a mechanical speedometer, then you won't be able to correct it – at least not using this circuit.

Power supply

Power for the circuit is applied via diode D1, which provides reverse polarity protection. Zener diode ZD1 and the 10Ω resistor provide transient protection to protect the input of REG1. The 100µF capacitor at REG1's input provides a further degree of transient voltage suppression. A 10µF filter capacitor is provided directly at REG1's output and the 100µF and 100nF capacitors decouple the supply to IC1.

An 8.2V supply is derived from the supply at REG1's input via a 220Ω resistor and Zener diode ZD3. This supply is for the pull-up resistors if required.

Software

The software files are available for free download via the *EPE* Downloads site, access via **www.epemag.co.uk**. Pre-proggrammed PICs are available from **Magenta Electronics** – see their advert in this issue for contact details.

Construction

The Super Speedo Corrector circuit fits onto a small PC board measuring 106 × 60mm. This board is available

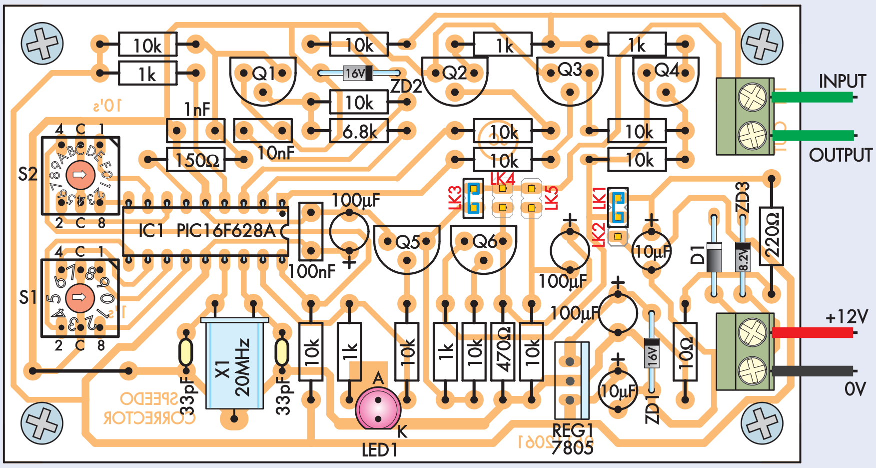
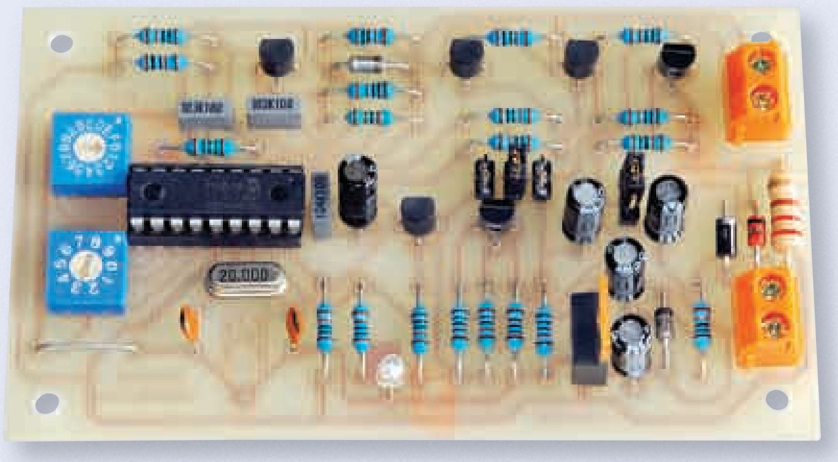


Fig.2: when assembling the PC board, take care with the orientation of the BCD switches, the PIC and the other polarised components. Use this diagram and the photos of the completed project (below) to help you in your assembly.



Corrections are easy to dial-up – just set the two rotary switches to give the up or down percentage correction that's needed. Here, the Super Speedo Corrector is configured to reduce the speedometer reading by 3%.

from the *EPE PCB Service*, code 682. The board topside component layout is shown in Fig.2.

Construction is straightforward, but be sure to correctly install the polarised components, such as the PIC microcontroller, electrolytic capacitors and the diodes. Note that transistors Q4 and Q6 are not the same type as Q1, Q2, Q3 and Q5, even though they look the same.

The BCD switches must be mounted with their dots positioned as shown on the overlay diagram (Fig.2). The BCD switch with 0-9 capabilities is S1 and the BCD switch with 0-F on it is S2.

Making adjustments

The speed reading can be altered in 1% increments. This is most easily explained if you use a test speed of 100km/h. If the speedometer is wrong by 5km/h at 100km/h, the adjustment needed is about 5%.

Switch S1 (the one nearest the bottom, when the PC board is orientated with the connections at the right) corrects the speedometer reading in single units and S2 changes the output in tens. So when you want a correction of 5%, simply set S1 to '5' and S2 to '0'. If the required correction is 16%, set S1 to '6' and S2 to '1'.

Using the two BCD switches in combination allows the speedometer reading to be altered by as much as 99%, in increments of just 1%.

The default output reduces the reading of the speedometer. This default was picked because most speedometers read fast (often by about 5%). Alternatively, if you wish to increase the speedometer reading, set S2 to its F position and wait for a two-flash acknowledgement from the LED. This needs to be done with the unit connected and powered up.

You will need an accurate reference to set the speedometer. This can be provided by a handheld GPS, another car with a known accurate speedometer or even, if you ask nicely, a police car. *Just make sure that you have an assistant to do the adjusting as you drive!*

You can also use the 'speedo check' distances that are marked on some roads – although strictly speaking, this is intended for checking the accuracy of the odometer rather than the speedometer.

Tacho as well?

The Super Speedo Corrector will also work with electronic tachos that take their feed from the ECU (ie, all cars with engine management).

The configuration procedure is the same as for use of the device as a speed interceptor, except that the 'speed sensor' becomes the tacho output signal from the ECU. This application is particularly suited to engine and gearbox swaps.

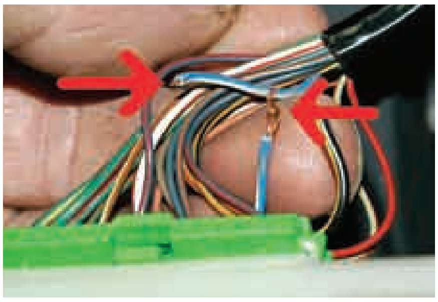
24V operation

The Super Speedo Corrector can be used on 24V vehicles if the following changes are made: change ZD1 to 33V 1W; change the 220Ω 0.5W resistor that feeds ZD3 to 1kΩ 1W; change the 100µF 16V capacitor at the input to REG1 to 100µF 35V.

Non-linearity?

The Super Speedo Corrector will not compensate for non-linear errors. In other words, if the speed reads 10% high at 25km/h and 4% high at 100km/h, you won't be able to use the Super Speedo Corrector to get the speedometer accurate at all speeds. However, most speedometer errors are proportional and so can be dialled out with the Speedo Corrector.

Finding the speed input wire to the speedometer can involve a dash disassembly job. In this Honda, the steering column had to be dropped, the dash fascia removed and the speedometer cluster unbolted and pulled forward. Make sure you're aware of the safety precautions that need to be taken if the car is equipped with airbags.



Once located, the speed sensor wire must be cut. The wire that goes to the speed sensor connects to the Super Speedo Corrector's 'IN' terminal and the wire going to the speedometer connects to the 'OUT' terminal.

Installation

Now for the installation – but first, a word of warning: if you need to pull the dash out to locate the speed input wire to the speedometer, make sure you're aware of the safety precautions that need to be taken if the car is equipped with airbags.

Of course, you must also check that you are not invalidating any manufacturers warranties that may still be running.

In the vast majority of cars, little setting-up will be needed – the corrector will mostly work out for itself what configuration is required. These are the steps to follow:

1) Connect power (use an ignition-switched source), ground, speedometer 'in' and speedometer 'out' (to the Speedo). Position the corrector so that a passenger can observe the on-board LED.

2) Set S1 to 2.

3) Set S2 to A.

4) Install link LK2.

5) Drive the car for a minute (the Speedo will not work).

6) Observe that the LED flashes at 1Hz when the car is moving. This shows that the Speedo Corrector has set itself for the type of speedometer signal that is present and is receiving a valid signal from it.

If the LED doesn't flash, install link LK1 (instead of LK2) and try again.

7) Set S2 to 0

8) Set S1 to 0

Table 1: Functions of S2 settings

Switch setting	Function	IC1 pin status
A	Autoset (automatically finds a suitable input setting)	Pins 1, 2 and 3 change. Pin 17 goes from 0V to 5V to 0V at a one-second rate to flash LED when automatic sensing is complete
B	Pull-up resistor (low sensitivity @ 2.5V peak)	Pin 1 @ 5V, Pin 2 @ 0V, Pin 3 @ 0V
C	AC input (high sensitivity @ 0.7V peak)	Pin 1 @ 0V, Pin 2 @ 0V, Pin 3 open circuit
D	Pull-down resistor (low sensitivity @ 2.5V peak)	Pin 1 @ 0V, Pin 2 @ 5V, Pin 3 @ 0V
E (initial setting)	No pull-up resistor or pull-down resistor (low sensitivity @ 2.5V peak)	Pin 1 @ 0V, Pin 2 @ 0V, Pin 3 @ 0V
F (default is slow)	Fast or slow option (LED acknowledgement: 1 flash = slow, 2 flashes = fast)	

Note 1: in most applications, only the 'A' (automatic) setting will need to be used during set-up.
Note 2: switch setting must be selected for a minimum of four seconds to initiate new function.

Digital speedometer lag

If the Speedo Corrector is fitted to a car with a digital speedometer, some lag may occur in the action of the speedometer. Typically, this is noticeable when abruptly coming to a stop from a slow speed (eg, 10km/h), where the speedometer may keep displaying a number greater than zero for up to a second, even when the car is stationary.

Lag may also make itself evident when moving away from a standstill, where the speedometer initially shows 0km/h before then jumping to 15km/h or 16km/h.

This problem can be overcome by the use of the special 'digital speedometer function' built into the Corrector. This function is enabled during set-up by setting switch S1 to a position other than 2 before selecting A on S2. Positions 1 to 9 on S1 vary the number of pulses for which the Speedo Corrector calculates the output frequency of the speedometer sensor (odd switch numbers calculate over one pulse and even numbers calculate over two pulses) and the time delay before the corrector stops sending a signal to the speedometer after the input signal ceases.

The delays are: positions 0,1 (1 sec); positions 2,3 (500ms); positions 4,5 (250ms); positions 6,7 (125ms); positions 8 and 9 (62.5ms).

If the speedometer reading noticeably lags behind actual vehicle speed, try different positions of S1 before each time setting S2 to A and proceeding with the self set-up process described in the main text. The optimal setting is that which gives the shortest lag while still reliably operating the speedometer.

Parts List

1 PC board, code 682, available from the *EPE PCB Service*, size 105 × 61mm
1 UB3-type plastic box, size 130 × 68 × 44mm
2 2-way PC-mount screw terminal blocks
1 18-pin DIL socket
3 2-way 2.5mm jumper headers
1 3-way 2.5mm jumper header
2 jumper shunts
1 0-9 BCD rotary switch (S1)
1 0-F BCD rotary switch (S2)

Semiconductors
1 PIC16F628A-I/P microcontroller, programmed with speedcor.hex (IC1)
4 BC337 NPN transistors (Q1,Q2,Q3,Q5)
2 BC327 PNP transistors (Q4,Q6)
1 7805 +5V voltage regulator (REG1)
1 1N4004 1A diode (D1)
2 16V 1W Zener diodes (ZD1,ZD2)
1 8.2V 1W Zener diode (ZD3)
1 3mm high-intensity red LED (LED1)
1 20MHz crystal (X1)

Capacitors
3 100μF 16V PC electrolytic
2 10μF 16V PC electrolytic
1 100nF MKT polyester
1 10nF MKT polyester
1 1nF MKT polyester
2 33pF ceramic

Resistors (0.25W 1%)
11 10kΩ
1 6.8kΩ
5 1kΩ
1 470Ω
1 220Ω 0.5W
1 150Ω
1 10Ω

9) Try the link options LK3, LK4 or LK5 until Speedo works (the speedometer should read as it did with the car standard).

10) Set S1 and S2 to give the required correction (S1 is for single units, S2 for tens).

11) If the speedometer reading needs to be corrected upwards rather than the default downwards, set S2 to F and then wait for the LED to flash twice. Then set S2 back to its required correction value. To return to downwards speed correction, again set S2 back to 'F' and wait for a single flash acknowledgement.

If the required settings are already known (eg, in the case of auto electricians fitting large numbers of the design to just one type of car), Table 1 shows how S2 can be used to manually set the input configuration, while Table 2 shows the output configurations achievable by the different link positions. Any changes to the switches will not be registered by the circuit until after about four seconds, so make sure you don't switch off power during this time! This delay allows you to rotate the switches to the required position without any unwanted changes occurring.

Table 2: Link functions

Link	Function
LK1	8.2V max. output
LK2	5V max. output
LK3	Pull-up output
LK4	Pull-down output
LK5	AC output

Conclusion

Once the Corrector is working properly, it can be mounted in a UB3-type plastic box and tucked up behind the dash out of sight. But don't assume that your speedometer is always going to be dead accurate – accuracy depends on tyre diameter, which changes with wear and when new tyres are fitted.

Of course, with the Super Speedo Corrector, it's easy enough to then make the required speedometer calibration change! *EPE*

Colour conumdrums

TechnoTalk

Mark Nelson

How do you put the colour into the cheeks of people appearing in black and white films and photos? State-of-the-art techniques exist for colourising old images, and even recovering colour information once considered lost, as Mark Nelson explains.

Fifty years ago, the Hollywood movie mogul Samuel Goldwyn was not convinced of the claims made for colour television. Famously, he declared, "I won't believe it until I see it in black and white." Whether the irony was intended is not recorded. Personally, I find black and white images much more relaxing, but I know I'm in a minority on that score.

Heresy in the 21st century

In fact, many viewers find black and white television and films a total turn-off, which is why there is so little monochrome material in today's television schedules, despite the obvious merit of much archive programming.

The major studios have tackled this aversion to monochrome by colourising some classic films that were made in black and white, and quite recently the same heresy has been carried out for television on footage of the First World War. Personally, I found the results rather unconvincing but your mileage may vary.

A different situation applies where the dyes in old colour film have faded and here computer processing can often restore the richness of the original hues. Eastmancolor is one of the most vulnerable of colour film processes and prints can fade in as little as five years if you are unlucky. Technicolor, on the other hand, is considered the most fade-resistant colour process.

A colour challenge of an entirely different kind is one that the BBC is addressing right now, namely recovering the colour information locked invisibly in black and white film recordings of 'lost' colour programmes. In the early days of colour television in Britain (we're talking about the late 1960s) videotape was simply too expensive to use as an archiving medium. At that time, each reel of tape cost about the same as a small car.

Selected programmes – particularly those that had an export potential – were, however, recorded on black and white film, effectively by pointing a cine camera at a television screen. The film stock used for these 'telerecordings' was monochrome, because it was cheaper and few Commonwealth countries (the prime export market for BBC Enterprises) transmitted in colour anyway.

Good news

As it happens, the BBC has a large number of black and white telerecordings of colour programmes for which no tape exists. Even better, some 98 per cent of these programmes were recorded without the colour chroma filtered off. Now why is this technical trivia such good news?

In fact, trivial it is not. Back in the 1960s, the then-new PAL colour television process was designed to be compatible with the large number of black and white sets already in use at that time. It achieved this objective by concealing the colour information within a 4.43MHz subcarrier signal superimposed on the monochrome picture signal.

This additional colour signal was outside the display capability of most TV receivers, but can be detected as a slight fuzziness on a very good quality monochrome monitor screen. For an optimum black and white telerecording the BBC engineers should have filtered out electronically this interference signal (known as chroma information) but often this extra task was overlooked.

Applied electronics

What this means is that the colour in these 40 year-old programmes may not be lost after all. Using the latest technology, BBC research staff have been experimenting with a process to scan film recordings at high-definition (HD) standard and then pick out the PAL chroma signal. The process looks very promising, making a large number of programmes from 1968 to 1974 capable of being brought back to full colour.

Candidates for recovery include science fiction such as *The Year of the Sex Olympics* and *Doctor Who*, the *Morecambe and Wise Show* and music programmes like *Top of The Pops* and *The Old Grey Whistle Test*, all of which will become far more palatable with the colour restored. How soon we shall see these on our screens at home is still to be determined, but BBC Worldwide (the new name for BBC Enterprises) has a clear commercial interest in releasing archive content.

It's important to stress that the process used here is not a colourisation process as such; it does not apply new colour to old programmes, but instead recreates the original colour from the film. Decoding the colour from a forty year old monochrome film print is a far greater technical triumph than anything carried out previously. The BBC did some work of this kind in the early 1990s, but the results were quite feeble in comparison.

Clever guys

The person leading this ground-breaking research is James Insell, founder of the Colour Recovery Working Group (**http://colour-recovery.wikispaces.com/**). Although James works for BBC Research, this website is entirely independent and is a discussion area for people producing software and systems that can be used by any broadcaster to recover colour information from archive film.

He says that the notion of recovering chroma captured in monochrome film came to him first in 1994 when viewing a film recording of the *Doctor Who* series called *Ambassadors of Death*? Six years later he put forward a theory for recolourising recordings to Steve Roberts of the BBC's *Doctor Who* restoration team. It took several years to secure funding and support for a research project, but now James has the supreme satisfaction of seeing his theory proved with amazing results.

Also involved in the project is Richard Russell, whose name you may recognise as the creator of the BBC BASIC for Windows computer language, and the author of the Z80 and MS-DOS versions of BBC BASIC. He designed several electronic colour test cards for the BBC, as well as versions for hobbyists. Richard's own website is at **www.rtrussell.co.uk/**.

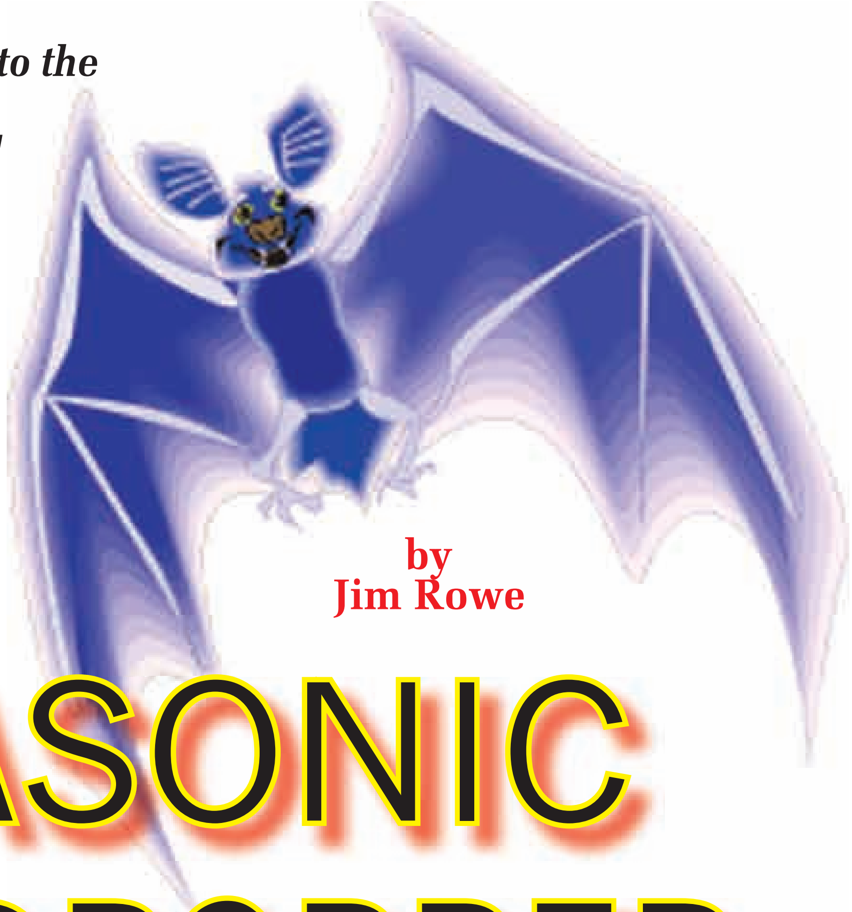
Want to try this at home?

Unfortunately, as much as you might like to, you cannot try this at home! But you can at least read about the techniques on the websites mentioned. On the other hand, you can try your hand at computer colourisation, adding colour to old photos, picture postcards and suchlike. This work can be extremely absorbing, with remarkably impressive results that get even better as you build up your skills. The program to use is called *Recolored* and you can download a free 21-day trial version from their website at **www.recolored.com/**.

A palette of colours allows you to pick the most realistic tints for flesh tones, grass, sky and all other objects in the photograph. Unlike many graphics programs, there is no need to struggle with layers or complicated settings. Everything is accomplished with a few brush strokes, with the software performing the otherwise difficult and time consuming task of colouring the image and creating smooth transitions between different coloured objects.

The Gallery section of the website shows some stunning examples of work with this program, and it's important to stress that the results look like colour photos rather than tints applied crudely on top of a black and white image. The software is not expensive (around £15) and the only shortcoming is the lack of a health warning saying how addictive this program can be!

Ever wanted to be able to listen to the 'unlistenable' – sounds that are way beyond the range of normal human hearing? Like the supersonic whine of a gas leak, or the echo-location 'chirps' of bats? Here's a low-cost project that will let you do just that. It's a down-converter, which shifts ultrasonic sound signals down into the frequency range where they can be heard (or recorded).



by
Jim Rowe

ULTRASONIC EAVESDROPPER

A FEW WEEKS AGO, I found myself watching a wildlife documentary on TV in which naturalists were studying the behaviour of bats. They were using infrared lighting to photograph them and a down-converter so that they could hear and record the ultrasonic 'chirps' that the bats use for navigation in the dark – and often for tracking down their insect prey/food.

My curiosity was aroused and I decided to 'have a go' at coming up with a low-cost down-converter of my own. This project is the end result, presented so that readers can also indulge their curiosity.

I won't claim that the project has all kinds of uses, because it's mainly going to be useful for listening to the ultrasonic sounds emitted by bats and one or two other nocturnal insect-eating creatures.

But you should also be able to use it to track down the exact location of high-pressure gas leaks – which apparently also produce an ultrasonic whistle or whine. You could even use it to make sure an ultrasonic dog whistle is working. If Fido seems to be ignoring it perhaps his hearing has deteriorated like mine!

How it works

Most of the sounds emitted by bats are in the frequency range from about 15kHz to 50kHz, with a few extending up to about 150kHz and a small number extending down below 10kHz. So most of them are above the range of human hearing, and some well above. (Young people can often hear up to about 18-20kHz, but this upper limit generally falls as we grow older.)

The idea of the eavesdropper is to shift the ultrasonic sounds down in frequency, so they fall within our comfortable hearing range.

This is done by using the heterodyne principle, in much the same way as it's used in many radio receivers. Or more accurately, in exactly the same way as it's used in 'direct conversion' receivers: we mix the incoming ultrasonic signals with a continuous ultrasonic signal from a 'local oscillator'.

In the mixer, the two signals heterodyne or 'beat' together, generating signals which correspond to the sum and difference of the two frequencies. The 'sum' signal will be very high in the ultrasonic range – and thus even more inaudible – but the 'difference' signal is easily arranged to be much lower in frequency and therefore in the audible (to humans!) range.

You can see how this down-conversion system works from the block diagram in Fig.1. The ultrasonic sounds are picked up by a small electret microphone, which turns them into small ultrasonic electrical signals. This type of microphone has a frequency

response which extends well up into the ultrasonic region.

The signals are then passed through a preamplifier to boost them to a more useful amplitude (or level), where they can be passed into one input of a balanced mixer. The other input to the mixer is fed with a continuous ultrasonic signal produced by a tuneable 'local oscillator', so it can be varied in frequency from about 15kHz to 50kHz.

As a result, the output of the balanced mixer contains three main frequency components: the difference signals ($F_{IN} – F_{OSC}$) and ($F_{OSC} – F_{IN}$), and the sum signal ($F_{IN} + F_{OSC}$). The sum signal is obviously even higher in the ultrasonic range than F_{IN} and F_{OSC}, so it's of no interest to us. We filter it out, anyway. But by adjusting the tuning of the local oscillator the difference signals can be placed down in the audible range, so all we have to do is feed them through an audio amplifier (via a volume control), so that they can be either heard though a pair of headphones or sent to a tape or other recorder (even recorded on a computer hard disk or memory card for later analysis).

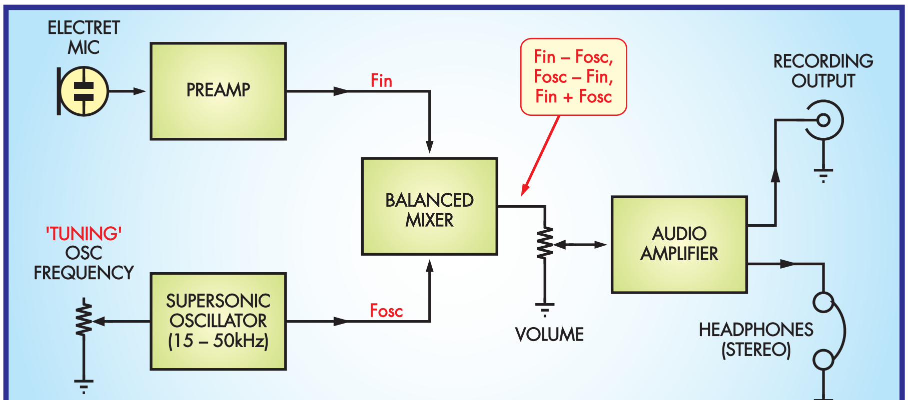
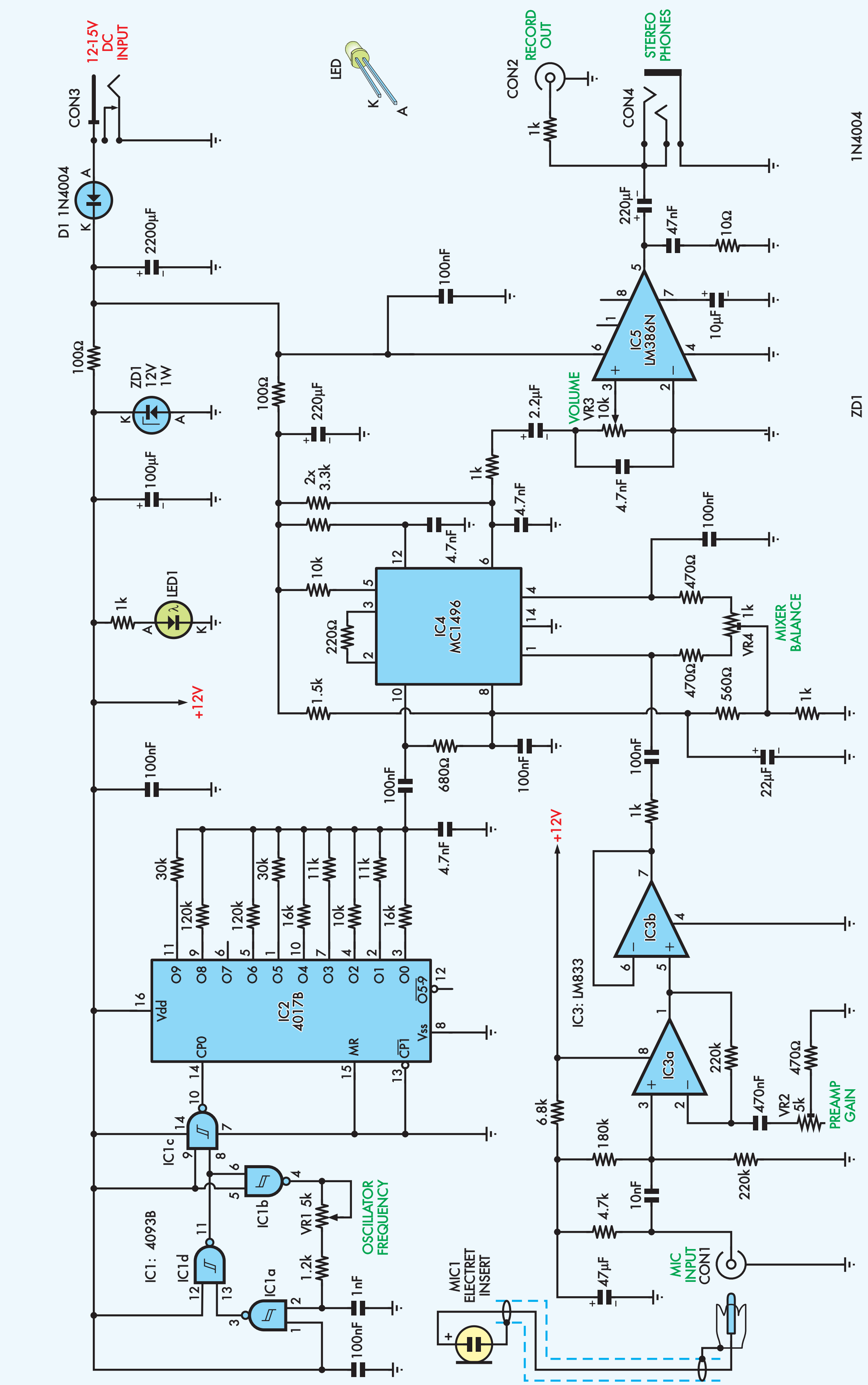


Fig.1: this block diagram shows the various functional elements of the Ultrasonic Eavesdropper.

What's with the dish?

Used by itself, the electret microphone insert works – but not very well. To make it more effective, we concentrate the ultrasonic sound waves with a small, 'somewhat' parabolic dish.

As you may recall from previous projects, a parabolic dish reflects all the waves which strike it to its focal point. With the microphone insert mounted



ULTRASONIC EAVESDROPPER

Fig.2: the circuit beats the 'bat' frequency against the supersonic generator formed by IC1 and IC2.

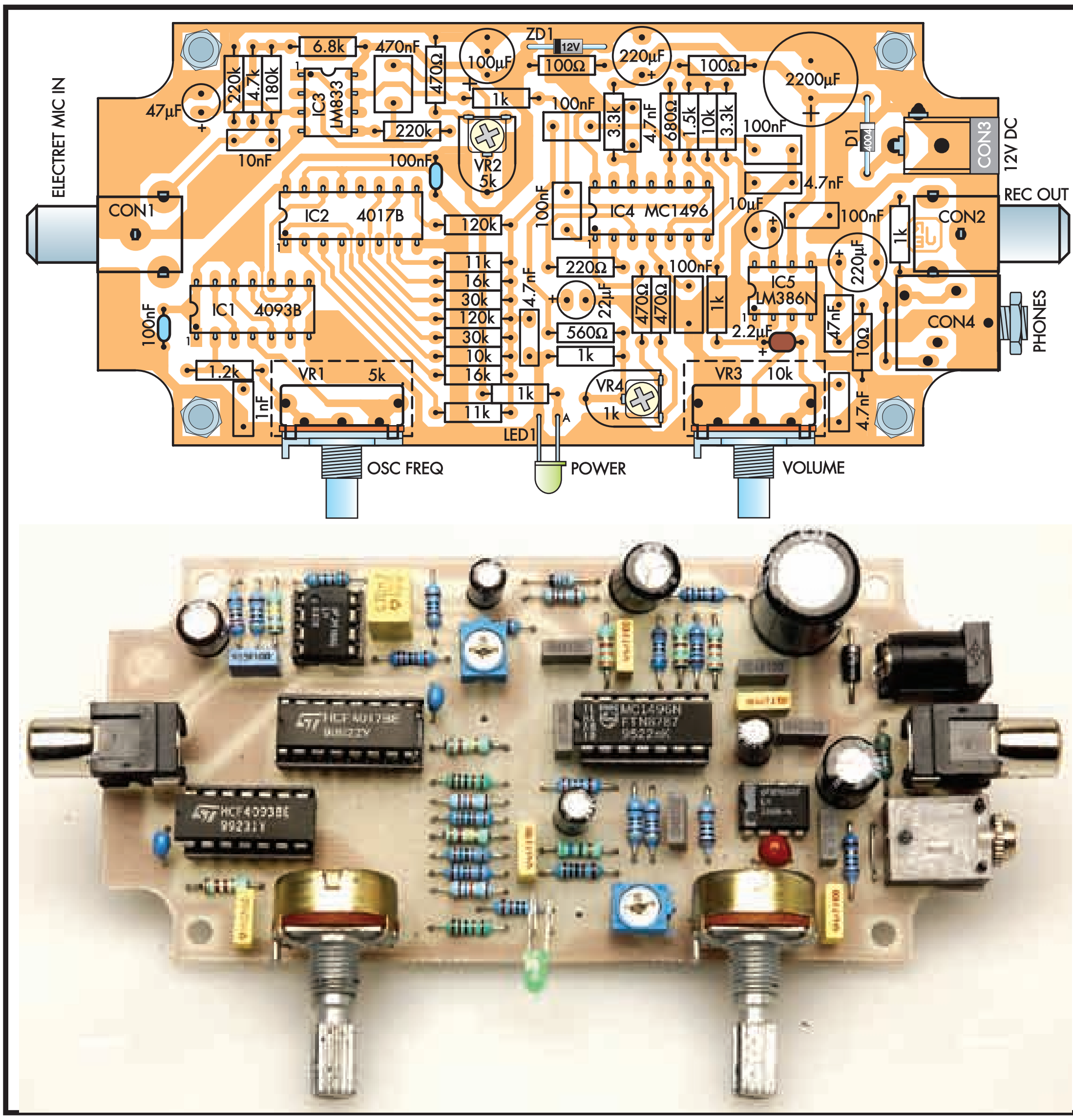


Fig.3: the entire project mounts on a single PC board, with the electret mic insert connected via an RCA phono socket on the left side. The sockets on the right connect power (12V DC), earphones and some form of audio recorder.

at the focal point (or as close as we can guess!), pick-up becomes much more efficient and effective.

This dish can be made from just about any material which will reflect sound waves – we used a laminated wood cereal or salad bowl, bought from a 'bargain store' for just a couple of pounds. It is about 155mm in diameter and about 39mm deep, but this is not at all critical – a larger dish should be even better, but would start to become unwieldy.

A similar (hard) plastic or even stainless steel salad bowl could also be used.

We said a moment ago that it was 'somewhat' parabolic in shape – it has a flat bottom. This might not be technically ideal but it is good enough for our purposes – and certainly makes it a lot simpler to attach things to!

You can work out the focal point of a parabola by formula (but it is complicated by the flat bottom), or you could line the bowl with aluminium foil and aim the bowl at the sun to enable you to get it spot on.

Another way of finding the focal point would be to connect the mic insert to an audio amplifier and aim the dish at a single point sound source (such as a speaker connected to an oscillator). Moving the microphone back and forward along the centre axis would reveal one point where the maximum signal was found.

Having said all that, we found near enough (an educated guess) was good enough – but feel free to experiment with distances! We'll look at mounting the dish and microphone a little later.

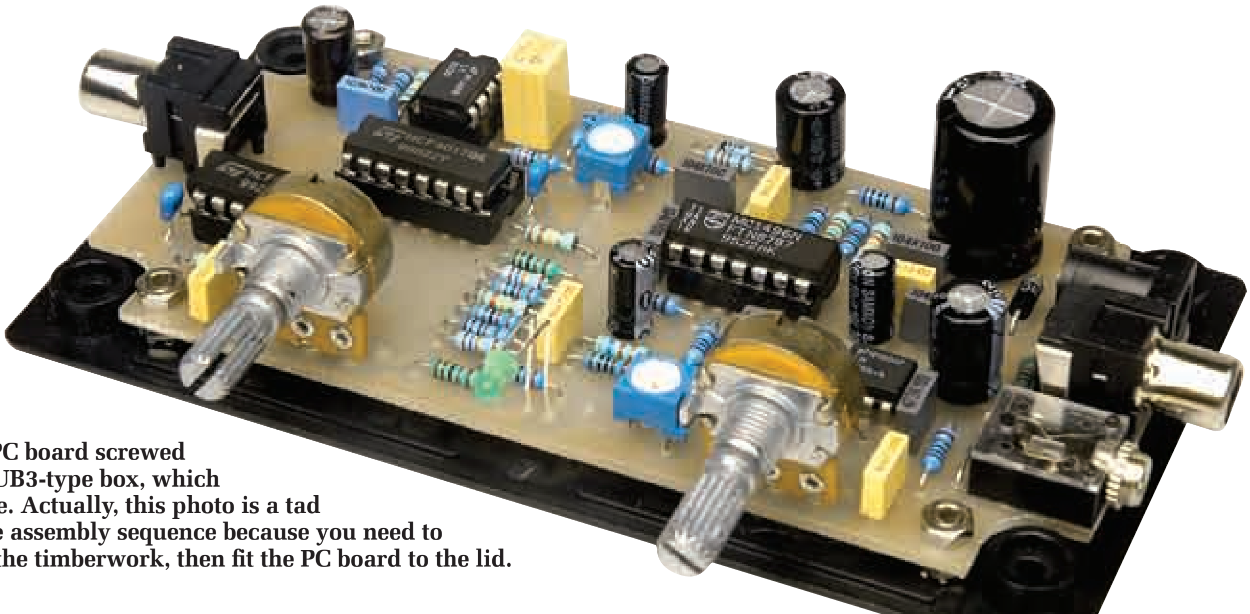
The circuit

Now let's look at the circuit diagram (Fig.2) for a more detailed understanding of how it works. The ultrasonic sounds are picked up by the electret microphone insert, MIC1.

The fairly small signals from MIC1 are fed in via CON1 and first amplified by IC3a, half of an LM833 dual low-noise op amp. It's used here as a preamp with its gain variable between about 40 and 400, using trimpot VR2.

This allows the project to be set up for either short or long range bat monitoring, and with bats having either loud or soft 'chirping' (they do vary between species).

After amplification, the signals are passed through IC3b, the 'other half' of the LM833, connected as a unity-gain buffer to provide a low impedance source feeding the mixer IC4, via a 1kΩ series resistor.



The completed PC board screwed to the lid of the UB3-type box, which becomes the base. Actually, this photo is a tad premature in the assembly sequence because you need to screw the lid to the timberwork, then fit the PC board to the lid.

Local oscillator

The ultrasonic signal used for our 'local oscillator' is generated using IC1 and IC2. This signal (a) needs to be tuneable over a fairly wide frequency range; (b) should be reasonably low in harmonic content and (c) should also be fairly constant in amplitude. However, this combination of qualities is not easy to produce using conventional audio oscillator circuits.

So we generate it in a slightly unusual fashion. Gates IC1a, IC1b and IC1d are used as a relaxation-type oscillator, producing a square wave clock signal which is variable between 150kHz and 500kHz using potentiometer VR1. This clock signal is buffered by gate IC1c and fed into the clock input of IC2, a 4017B Johnson-type decade counter.

This IC therefore counts the clock signals so that its 10 outputs, O0 to O9, switch high in turn, on a continuous cyclic basis. These outputs are used to drive a simple digital-to-analogue converter (DAC) using a set of resistors. While it may appear that output O7 is not used, it is – its 'infinite value' resistor (ie, open circuit) actually sets the zero point.

The values of the resistors are carefully chosen so that as the outputs of IC2 go high in turn, a 10-sample approximation of a sinewave is developed across the output (ie, the 680Ω resistor between pins 10 and 8 of IC4). The 4.7nF capacitor which is also across the output provides a measure of low-pass filtering and further 'smoothing' of the sinewave.

The result of this simple digital waveform synthesis is a fairly smooth sinewave signal of reasonably constant amplitude, with a frequency exactly one tenth that of the clock signal from IC1. So as the clock signal is varied between 150 and 500kHz via VR1, the 'local oscillator' sinewave signal at the pin 10 input of IC4 is varied between 15kHz and 50kHz.

Balanced mixer

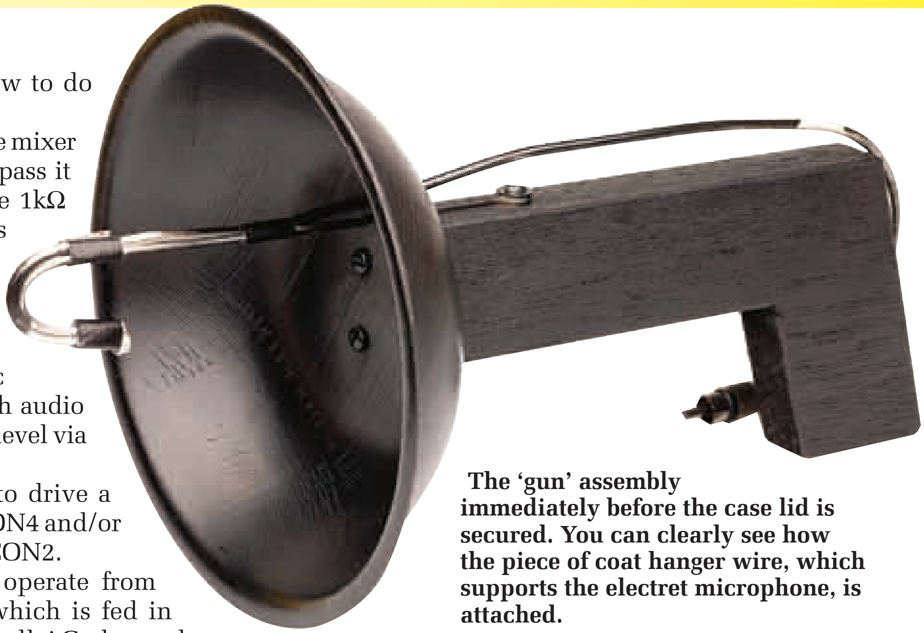
IC4 is an MC1496 double-balanced mixer, expressly designed for this kind of use. When we feed our amplified ultrasonic sound input signal into pin 1 and our local oscillator signal into pin 10, it performs an analogue multiplication between them and provides the corresponding sum and difference frequency signals at its outputs (pins 6 and 12, which are simply dual polarity outputs).

By the way, the mixer strictly only produces just the sum and difference signals at its outputs when it is carefully balanced using trimpot VR4. If it is not truly balanced, both of the input signals can also be present in the outputs – although this is not a major problem here because both of these input signals are inaudible.

All the same, it's a good idea to have the mixer reasonably close to balance, to reduce distortion

Here you can see how the plastic case needs to be drilled and slotted...

...so that the PC board is an easy fit. Again, the lid is screwed to the handle before the board is placed inside the box.



The ‘gun’ assembly immediately before the case lid is secured. You can clearly see how the piece of coat hanger wire, which supports the electret microphone, is attached.

in the audio amplifier. We’ll explain how to do this later.

As you can see, in this project we take the mixer output signal from pin 6 of IC4 and then pass it through a simple low-pass filter using the 1kΩ series resistor and 4.7nF capacitor (across volume control VR3). This filtering attenuates the ‘sum’ frequency components quite significantly, leaving mainly just the audible ‘difference’ components that represent the downshifted version of our ultrasonic sound signals. We then pass these through audio amplifier IC5, after adjusting their volume level via potentiometer VR3.

The amplified output of IC5 is used to drive a standard pair of stereo headphones via CON4 and/or an audio recorder via line-level output CON2.

The complete circuit is designed to operate from almost any source of 12V to 15V DC, which is fed in via CON3 and can come from either a small AC plugpack supply or a nominal 12V battery, such as that in a car or motorcycle.

The total current drain is less than 35mA, so you could also run it from a pair of 6V lantern batteries connected in series, or even a pack of eight C-cells. Zener diode ZD1 limits the voltage which can be fed to ICs 1 to 3, while LED1 indicates that power is applied.

Construction

All of the Eavesdropper circuitry is mounted on a single PC board, measuring only 122 × 57mm. This board is available from the *EPE PCB Service*, code 683. The component layout is shown in Fig.3. As you can see, the board has rounded cutouts at each corner so that it can be mounted snugly inside a standard plastic box measuring 130 × 68 × 44mm.

Microphone input socket CON1 is mounted on the left-hand end of the board, while the DC input, headphone output and recording output connectors are all mounted on the right-hand end. The local oscillator ‘tuning’ pot VR1, power LED1 and volume control pot VR3 are all mounted along the front side for easy access.

Begin construction by checking the PC board for any etching problems or undrilled holes and fixing these before you proceed. Then it’s a good idea to fit the various connectors (CON1 to CON4), as these sometimes require a small amount of fiddling and board hole enlargement.

There is only one wire link to be fitted to the board, so it’s suggested you fit this next to make sure it isn’t forgotten. It’s located just behind CON4 at lower right, as viewed in the PC board overlay diagram.

Next, fit the various fixed resistors, taking care to fit each one in its correct position. These can be followed by trimpots VR2 and VR4, making sure you don’t swap them around. The 5kΩ trimpot is VR2, while the 1kΩ trimpot is VR4. Don’t fit the two large rotary pots at this stage – they’re best fitted later.

Now you can fit the capacitors, starting with the two 100nF multilayer monolithics (near IC1 and IC2) and then progressing through the small MKT caps, the 2.2µF tag tantalum electrolytic (just to the front of IC5) and then the other electrolytics. Remember that all the electrolytics are polarised, so make sure you orient them correctly (as shown in Fig.3, the PC board overlay diagram).

After these you can fit the semiconductors, starting with diode D1 and Zener diode ZD1 – again, make sure you don’t

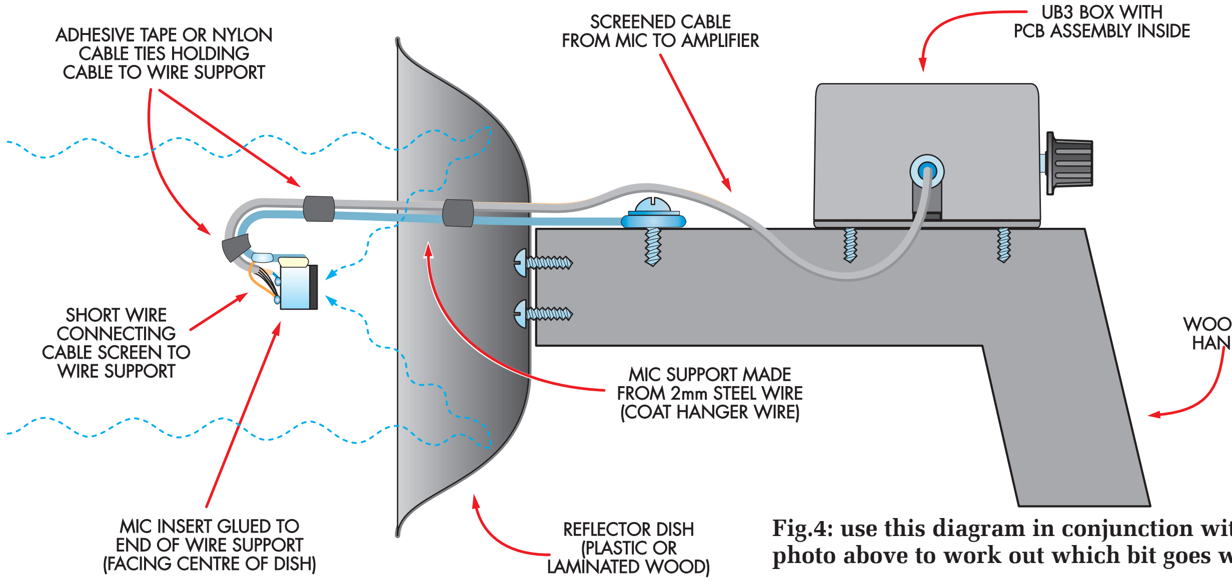


Fig.4: use this diagram in conjunction with the photo above to work out which bit goes where!

swap these accidentally and that they are both fitted with the correct orientation, as shown in the overlay diagram and photos. Then fit the ICs, preferably in reverse numbered order (ie, IC5 first, then IC4, working your way back to IC2 and IC1). Although there is no need to fit any of the ICs in sockets, we suggest that you do. All five ICs must be oriented as shown.

If you are soldering IC2 and IC1 directly into the board, take extra care to protect them from the possibility of electrostatic damage. Use an earthed soldering iron, earth yourself if possible (or at least discharge yourself before handling the ICs) and solder the supply pins of the ICs first (pins 7 and 14 on IC1, pins 8 and 16 on IC2) to enable their internal protection circuitry as early as possible.

After the ICs are in position, it's time to fit power LED1. This is fitted to the board vertically to begin with, with its longer anode (A) lead to the right and both leads soldered to their pads underneath with the LED's body about 18mm above the board. Then, using a pair of needle-nose pliers or similar, bend both leads forward by 90°, 12mm above the board. This will position the LED facing forward and ready to protrude through the matching hole in the box, after final assembly.

The last two components to mount on the board are control pots VR1 and VR3, which are both fitted along the front of the board on either side of LED1. You may need to cut the pot spindles to about 10-12mm long before they're

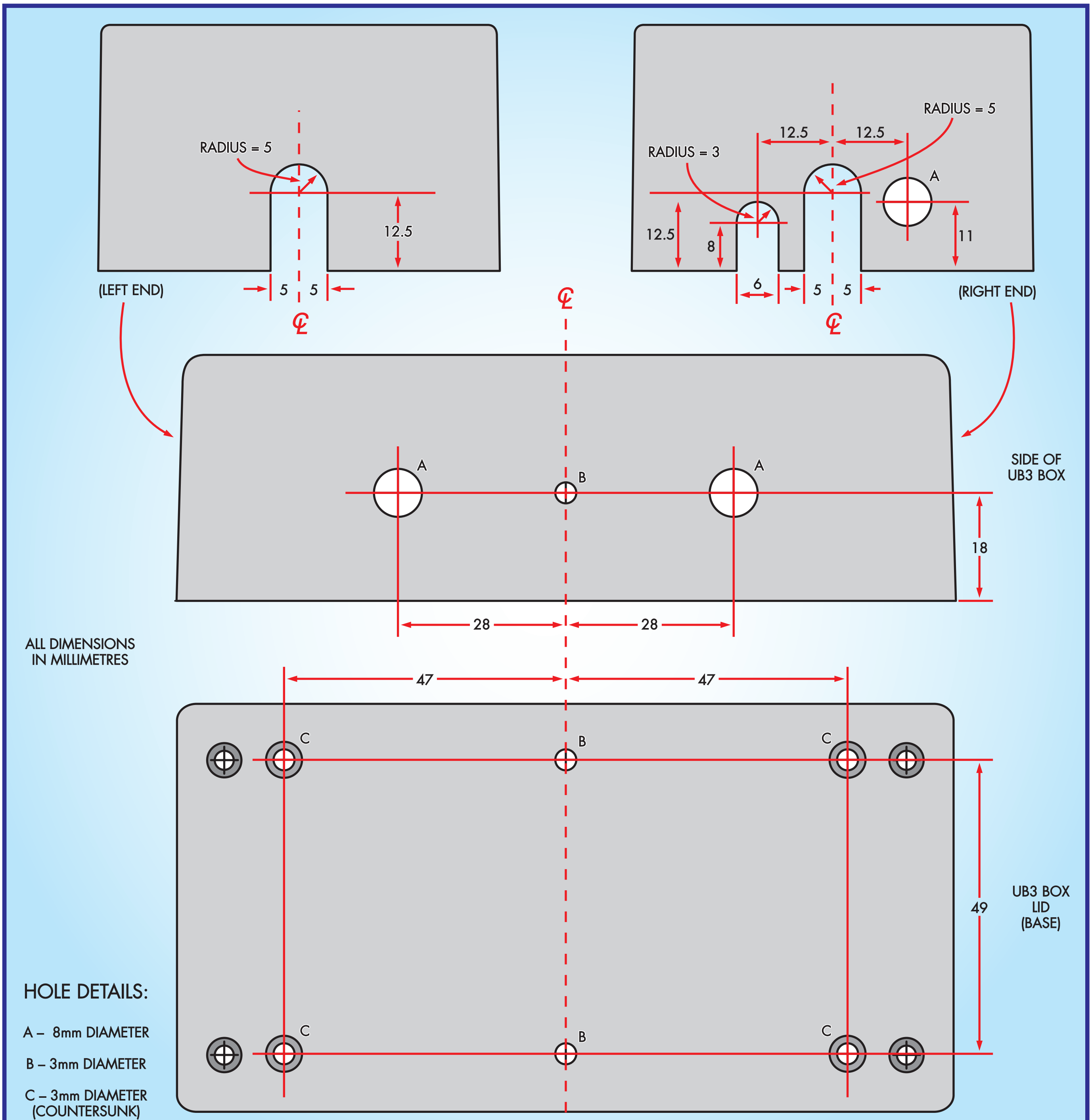


Fig.5: hole drilling diagram for a UB3-type plastic box.

fitted, if they're not already this length. Make sure you fit the 5kΩ linear pot as VR1, and the 10kΩ log pot as VR3, as shown in the overlay diagram.

Your Eavesdropper board should now be complete and ready to be fitted to the lid of the UB3-type plastic box, which is used here as the base. But before doing this, you may need to prepare both the lid and the box itself, by drilling and cutting the various holes that are needed for mounting, assembly and access to the various connectors and controls. The location and dimensions of all of these holes are shown in the drilling diagram (Fig.5), so you shouldn't have any problems if you use this as a guide.

The hardware

It would also be a good idea at this stage to make the Eavesdropper's wooden 'handle' and attach it to the front small reflector dish we mentioned earlier.

The dish is simply attached to the front of the wooden handle using a couple of 15mm-long self-tapping screws, passing through 3mm holes drilled in the centre of the 'bowl'. Two further 3mm holes were drilled just above these mounting holes to allow the mic support 'bracket' and its shielded lead to pass through – see Fig.4.

The mic support bracket was bent up from a 200mm length of 2.2mm diameter steel wire, salvaged from a coat-hanger. After straightening and cutting to length, the wire was bent into a small loop at one end (around the shank of a 4mm twist drill). Then the straight section of wire was passed through the matching hole in the back of the dish, and the loop end attached to the top of the wooden handle, about 45mm behind the bowl, using a 15mm-long wood-screw, with a small flat washer under the screw head.

The front end of the bracket was then bent around and downwards in an open J-shape, about 20mm in diameter, so the end was aligned very closely with the centre axis of the bowl and about 65mm in front of the bowl's inside centre – corresponding to an approximation of this bowl's likely 'focus' as an ultrasonic reflector.

Then the mini electret mic insert was cemented to the side of the wire's end using epoxy cement, with its 'front' facing inwards towards the centre of the bowl (ie, it looks backwards, not forwards).

After the epoxy cement has cured, solder the wires at one end of a 300mm length of light duty, screened microphone cable to the mic insert connection pads, with the cable screen wires connected to the insert's earthy/case pad and the inner wire to the other '+' pad. This is a slightly tricky job, as the pads are very small and closely spaced. So take your time, and in particular take care not to overheat the mic insert.

If you're new to soldering, it might surprise you to find that a hot, well-tinned iron poses much less danger than a cooler iron. The solder job is completed much more quickly – before the insert has had a chance to realise it's getting hot!

It's also a good idea to connect the cable screen to the wire support bracket just near the mic using a short length of fine tinned copper wire, to minimise hum pickup. The free end of the mic cable is then passed back through the remaining hole in the centre of the bowl and fitted with a metal-shelled RCA phono plug at the other end, ready to plug into the Eavesdropper. To prevent the cable from flapping around, it can be fastened to the mic supporting wire using three short lengths of 'gaffer' tape (visible in the photos) wrapped around them both.

At this stage, we gave the whole assembly a couple of coats of matt black spray paint. It looks 100% better than leaving it 'au naturel', which simply looks like a wooden salad bowl screwed to a piece of timber. If you do this, don't forget to completely cover the electret mic insert in adhesive tape to stop it getting painted. Masking tape is preferable because ordinary adhesive tape can be a real pest to remove.

Parts List – Ultrasonic Eavesdropper

1 PC board, code 683, available from the *EPE PCB Service*, size 122 × 57mm
1 plastic UB3-type box, size 130 × 68 × 44mm
2 RCA phono sockets, PC-mount (CON1, CON2)
1 2.5mm DC power socket, PC-mount (CON3)
1 3.5mm stereo jack socket, PC-mount (CON4)
1 Electret mic insert, miniature type (MIC1)
1 300mm length of screened mic cable
1 RCA phono plug, metal screened type
4 10mm long M3 machine screws, countersink head
4 M3 star lockwashers
8 M3 nuts
2 Small control knobs (for VR1 and VR3)

Semiconductors
1 4093B quad Schmitt NAND gate (IC1)
1 4017B decade counter (IC2)
1 LM833 dual low-noise op amp (IC3)
1 MC1496 double-balanced mixer (IC4)
1 LM386N audio amplifier (IC5)
1 12V 1W Zener diode (ZD1)
1 3mm green LED (LED1)
1 1N4004 1A diode (D1)

Capacitors
1 2200µF 16V RB electrolytic
2 220µF 16V RB electrolytic
1 100µF 16V RB electrolytic
1 47µF 16V RB electrolytic
1 22µF 16V RB electrolytic
1 10µF 16V RB electrolytic
1 2.2µF 35V TAG tantalum
1 470nF MKT metallised polyester
5 100nF MKT metallised polyester
2 100nF multilayer monolithic
1 47nF MKT metallised polyester
1 10nF MKT metallised polyester
4 4.7nF MKT metallised polyester
1 1nF MKT metallised polyester

Resistors (0.25W 1%)

2 220kΩ	1 180kΩ	2 120kΩ	2 30kΩ
2 16kΩ	2 11kΩ	2 10kΩ	1 6.8kΩ
1 4.7kΩ	2 3.3kΩ	1 1.5kΩ	1 1.2kΩ
5 1kΩ	1 680Ω	1 560Ω	3 470Ω
1 220Ω	2 100Ω	1 10Ω	

1 5kΩ linear pot, 16mm or 24mm PC-mount (VR1)
1 5kΩ mini trimpot, horizontal PC-mount (VR2)
1 10kΩ log pot, 16mm or 24mm PC-mount (VR3)
1 1kΩ mini trimpot, horizontal PC-mount (VR4)

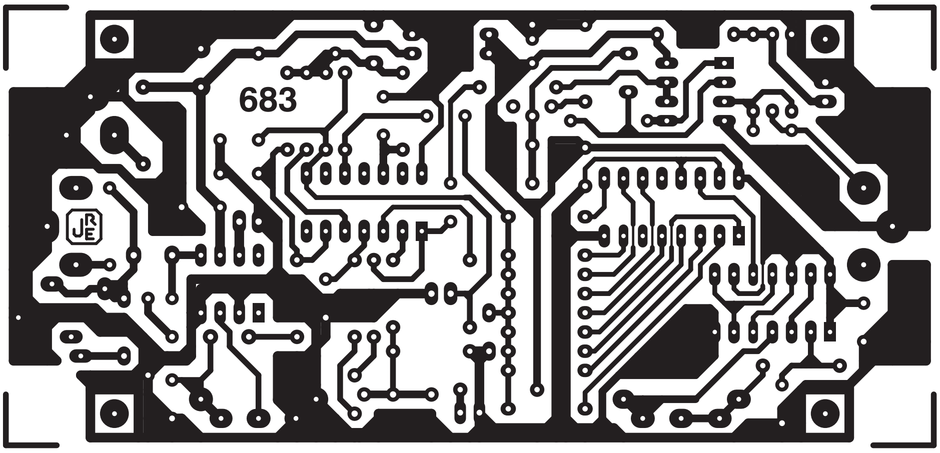


Fig.6 (above): the same-size PC board pattern, while below (Fig 7) is a same-size front panel artwork. We simply laminated and glued the paper label to the box, leaving a 2mm border around the edge.

Once the handle-dish-mic assembly is complete, you can attach the Eavesdropper's lid/base plate to the top rear of the wooden handle using a couple of 15mm-long woodscrews through the two 3mm holes in the centre. As you can see, the lid is orientated at right angles to the handle axis, and centred over it.

With the box lid attached to the handle, you can fit the Eavesdropper's finished PC board assembly on to the lid.

It's attached using four 10mm-long M3 machine screws with countersink heads, passed up from below, and each then fitted with a star lockwasher and M3 nut. These nuts act as spacers, so the screws and nuts should be firmly tightened before the board assembly is fitted. Then, when it is in position, four further nuts are used to hold it in place.

Checkout and adjustment

When the PC board assembly is fixed in place, it's time to fire up the Eavesdropper and give it a quick functional checkout.

Set both of the main control pots to roughly their midrange positions, and also set both trimpots to their midrange positions using a small screwdriver or alignment tool. Plug the mic cable into CON1, a pair of standard stereo

Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	2	220kΩ	red red yellow brown	red red black orange brown
❏	1	180kΩ	brown grey yellow brown	brown grey black orange brown
❏	2	120kΩ	brown red yellow brown	brown red black orange brown
❏	2	30kΩ	orange black orange brown	orange black black red brown
❏	2	16kΩ	brown blue orange brown	brown blue black red brown
❏	2	11kΩ	brown brown orange brown	brown brown black red brown
❏	2	10kΩ	brown black orange brown	brown black black red brown
❏	1	6.8kΩ	blue grey red brown	blue grey black brown brown
❏	1	4.7kΩ	yellow purple red brown	yellow purple black brown brown
❏	1	3.3kΩ	orange orange red brown	orange orange black brown brown
❏	1	1.5kΩ	brown green red brown	brown green black brown brown
❏	1	1.2kΩ	brown red red brown	brown red black brown brown
❏	5	1kΩ	brown black red brown	brown black black brown brown
❏	1	680Ω	blue grey brown brown	blue grey black black brown
❏	1	560Ω	green blue brown brown	green blue black black brown
❏	3	470Ω	yellow purple brown brown	yellow purple black black brown
❏	1	220Ω	red red brown brown	red red black black brown
❏	2	100Ω	brown black brown brown	brown black black black brown
❏	1	10Ω	brown black black gold	brown black black gold brown

Two views looking for'ard and aft. If you paint the whole shebang black, like we did, make sure you wrap a piece of masking tape around the microphone insert first. They don't like being covered in paint!

headphones into CON4 (but don't put them on yet, just in case something is wrong!) and the cable from your 12V battery or plugpack into CON3.

Power LED1 should immediately light up, to show that the circuit is operating. If the LED doesn't light, this will probably be because one of three components is fitted to the board with reversed polarity: LED1 itself, D1 or ZD1. Either that or the plug on your DC input cable is wired with reversed polarity.

With a multimeter, check the voltage between the anode of diode D1 and the board's ground – it should be the same as the incoming DC. Similarly, the voltage at the cathode of D1 should be only 0.6V lower, while that at the cathode end of Zener diode ZD1 should be a little lower again.

You should also be able to measure the same voltage at pin 14 of IC1, pin 16 of IC2 and pin 8 of IC3. Likewise, at pin 6 of IC5 you should find the same voltage as you measured at the cathode of diode D1.

Listen to the headphones without actually putting them on. If they are not shrieking, place the headphones on your ears and you should hear a small amount of noise and/or hum. If you turn up volume control VR3, this noise should increase a little, showing that the audio section of the circuit is working correctly.

Now try returning VR3 to its midrange position and adjusting 'tuning' control VR1 up or down. You may hear a faint heterodyne 'whistle' as you tune through one position in the tuning range. This is probably due to the mic preamp picking up a small amount of RF from a local AM radio station, which then heterodynes with the Eavesdropper's local oscillator or one of its harmonics. This is not likely to interfere with the Eavesdropper's normal operation, but if nothing else it shows that the Eavesdropper's local oscillator, ultrasonic preamp and mixer sections are all working.

If all seems well at this stage, your Eavesdropper is probably working correctly and all that remains to be done before final box assembly is to set the mixer 'balance' trimpot VR4 to the correct position.

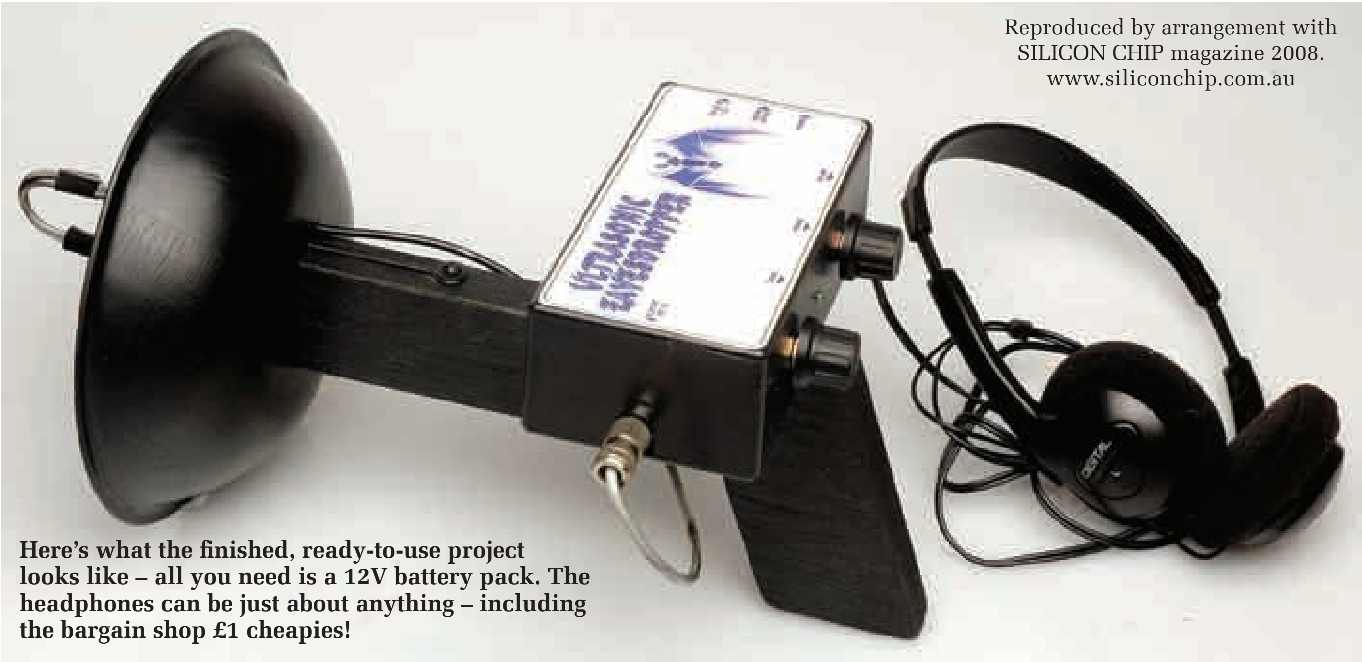
Got a 'scope?

Mixer balance adjustment is easiest with an oscilloscope, but if you don't have access to one, you don't really have to concern yourself about it; simply leave VR4 set to its midrange position, which is very likely to be 'near enough' for most purposes.

If you do have access to a scope and you want to set the mixer for the best possible performance, the adjustment is quite easy.

Capacitor Codes

Value	µF Code	EIA Code	IEC Code
470nF	0.47µF	474	470n
100nF	0.1µF	104	100n
47nF	.047µF	473	47n
10nF	.01µF	103	10n
4.7nF	.0047µF	472	4n7
1nF	.001µF	102	1n0



Here's what the finished, ready-to-use project looks like – all you need is a 12V battery pack. The headphones can be just about anything – including the bargain shop £1 cheapies!

All you need to do is monitor the level of the Eavesdropper's 'local oscillator' signal appearing at pin 6 of IC4 with your 'scope, while adjusting VR4 with a small screwdriver, or plastic trimming tool. At either end of the trimpot's range the signal will increase in level, while it will pass through a minimum or 'null' somewhere near the middle of the range.

The correct setting for VR4 is right at the *centre* of this null – this corresponds to the mixer being balanced.

Final assembly

The final assembly step is to fit the box itself down over the PC board assembly, as a protective cover.

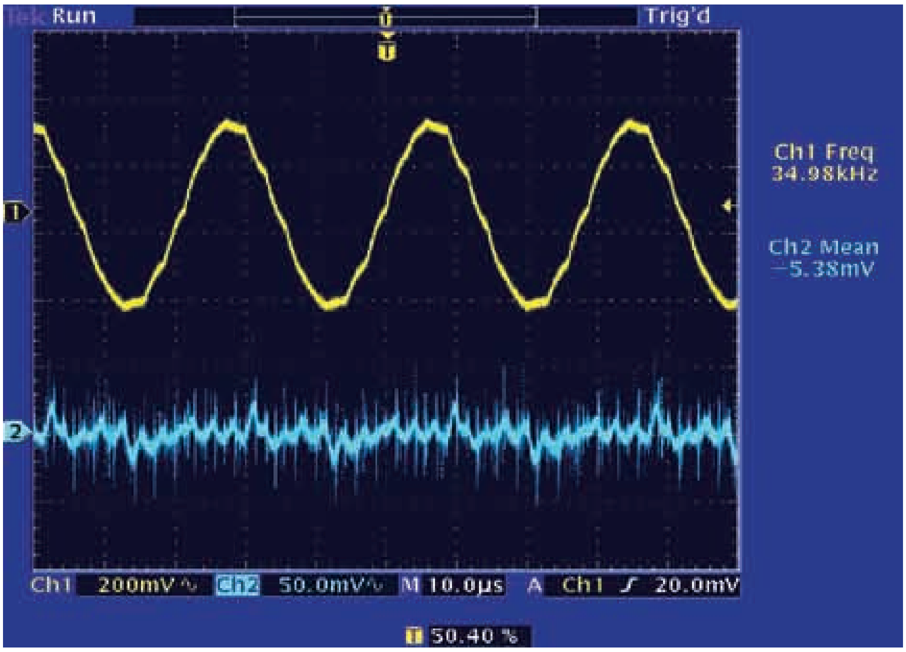
This is done by inverting the box and tilting it an angle of about 45° so that it can be offered up to the PC board with the control pot spindles and LED1 entering their matching holes on the box 'front side' from the inside.

Then the box is moved towards the mic and reflector bowl, gradually tilting it down so that the undrilled long side swings down outside the 220µF electrolytic and the other components along the rear of the board.

The slots at each end of the box will allow the ends to clear the protruding sleeves of RCA phono connectors CON1 and CON2.

When the box has been juggled into position, it can be attached to the lid/base using the four small self-tapping screws supplied with it. Then the control pots can be fitted with their nuts, which can also be lightly tightened to help support the pots when the Eavesdropper is being used.

After this, you can fit the knobs, and your Eavesdropper should be ready for use.



The top trace of this 'scope shot shows the synthesised sinewave coming from the ladder network of IC2. The lower (blue) trace shows the output at pin 6 of IC4. The very low mean voltage measurement of 5.38mV shows that the modulator is balanced.

Using it!

Operating the Ultrasonic Eavesdropper is very straightforward. You use 'tuning' pot VR1 to search for ultrasonic sounds over the Eavesdropper's range and then, when you find one, the same control is used to shift the sounds down to a convenient frequency for listening or recording. Volume control VR3 is used simply to adjust the output audio to a convenient level.

You'll probably find the Eavesdropper sensitive enough to pick up bat chirps with the preamp gain trimpot VR2 left in its suggested midrange position.

However, if you want to have the highest possible sensitivity, preset VR2 can be turned up to its fully clockwise position.

Happy bat tracking! ***EPE***

by JIM ROWE

S-video to composite video converter

Some digital TV set-top boxes provide only S-video and component video outputs, which can pose a problem if your TV set only has a composite video input – or you've used up the S-video and component video inputs. The same can happen with video tuner cards for PCs. Here's an easy-to-build adaptor to get you out of trouble.

YOU CAN BUY CHEAP S-video to composite video adaptors in bargain stores, but the unit described here will do a much better job.

Although those really cheap bargain-store adaptors do work, if you examine the pictures critically, you'll find that their quality leaves quite a bit to be desired. In particular, you'll find that wherever the image has large areas of fine detail – like a shirt with a fine striped or check pattern, or an exterior panning shot

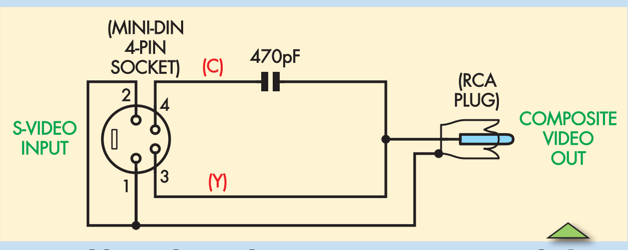
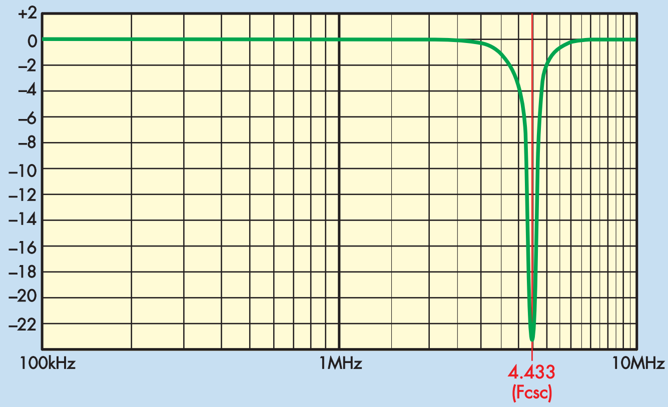


Fig.1: adding a low-value capacitor in series with the chrominance signal at the S-video input can reduce cross-colour interference, but also softens the picture.

Fig.2 (right): the unit described here uses an *LC* circuit to notch out a narrow band of frequencies centred on the 4.433MHz colour subcarrier frequency. This reduces cross-colour interference while leaving a sharp picture.



Low-cost 'bargain-store' adaptors commonly produce pictures that suffer from cross-colour interference, as shown in the photograph on the left. By contrast, the *S-Video Converter* dramatically reduces cross-colour interference – see photo on the right.

of a multi-storey building – then you'll see a very obvious coloured *Moiré* interference pattern, usually in shades of yellow and purple.

This effect is called 'cross-colour interference' and it's caused by heterodyne beats between the higher frequencies in the luminance (Y) signal and the chrominance (C) subcarrier in the receiver's decoder. In effect, the higher luminance frequencies tend to behave as if they were part of the chrominance signal, and as a result, produce fake colour patterns.

This happens when the two signals are simply mixed together in the video adaptor – which is what commonly happens in the bargain store units. This interference pattern can't happen when the Y and C signals are kept separate, which is why S-video produces much better image quality.

Reducing the interference

Some of the better low-cost adaptors try to reduce this cross-colour interference by adding a small capacitor in series with the chrominance input signal, as shown in Fig.1. The capacitor's value is chosen so that it passes most of the chrominance (C) information (it's in a band about 2.5MHz wide, centred on 4.43361875MHz), while at the same time attenuating the higher frequency luminance signals – ie, by shunting the luminance output into the chrominance output of the S-video signal source.

This reduces the cross-colour interference, although it also removes some of the fine detail from the images, so

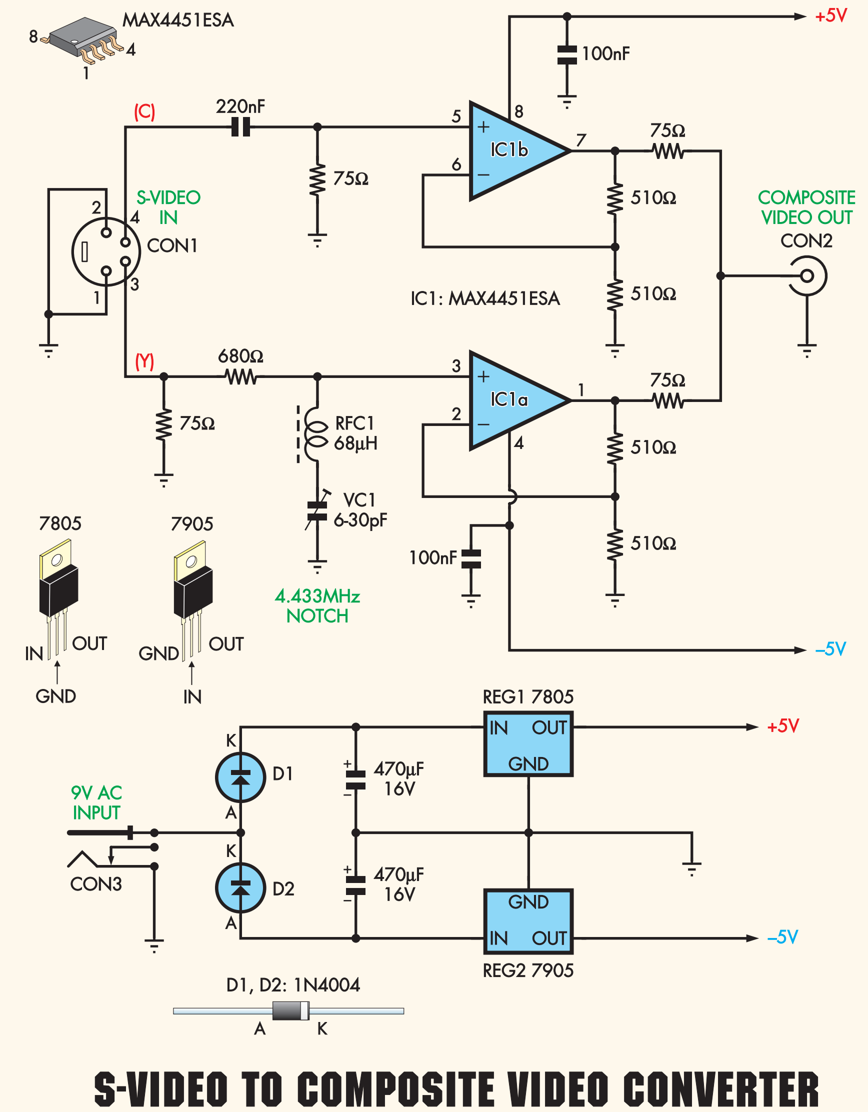
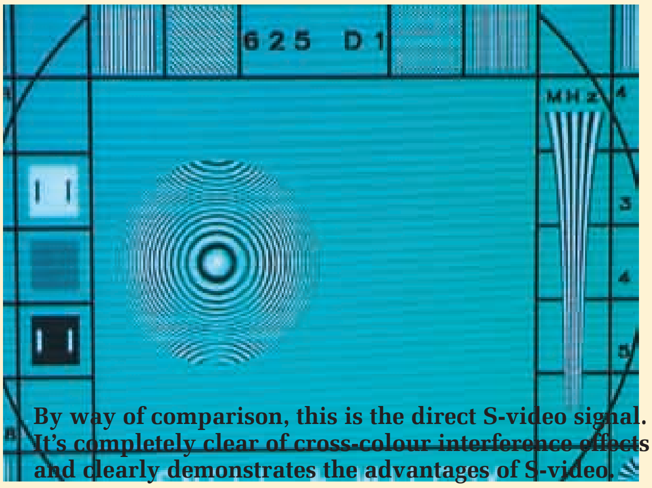


Fig.3: the circuit is based on a MAX4451 dual-wideband video amplifier IC, with each stage wired as a non-inverting amplifier with a gain of 2.0. Components RFC1 and VC1 provide the 4.43361875MHz notch in the luminance signal.

This screen shot shows the Snell and Wilcox moving plate test pattern fed through a 'cheapo' S-video to composite video converter. Note the obvious colour *Moiré* patterns on the moving plate section and in other areas where there are fine lines.

This is the same test pattern as above, but this time fed through the S-Video converter. As can be seen, the cross-colour interference effects have been dramatically reduced.



By way of comparison, this is the direct S-video signal. It's completely clear of cross-colour interference effects and clearly demonstrates the advantages of S-video.

Parts List – S-Video Converter

1 double-sided PC board, code 684, available from the *EPE PCB Service*, size 76 × 46mm
1 UB5-type plastic box, size 83 × 53 × 31mm
1 68µH RF choke (RFC1)
1 mini 4-pin DIN socket, PC mounting (CON1)
1 RCA phono socket, yellow, PC mounting (CON2)
1 2.5mm concentric power connector, PC mounting (CON3)
4 M3 x 10mm machine screws, countersink head
4 M3 star lockwashers
10 M3 nuts
2 M3 x 6mm machine screws, round/pan head

Semiconductors
1 MAX4451ESA dual video op amp (IC1)
1 7805 +5V voltage regulator (REG1)
1 7905 –5V voltage regulator (REG2)
2 1N4004 400V 1A rectifier diodes (D1,D2)

Capacitors
2 470µF 16V RB electrolytic
1 220nF MKT metallised polyester
2 100nF multilayer monolithic
1 6-30pF trimmer, green (VC1)

Resistors (0.25W 1%)
1 680Ω
4 510Ω
4 75Ω

they become softer – ie, the chrominance output is also shunted to some extent.

In contrast, the unit described here does a better job of reducing cross-colour interference without sacrificing the higher frequencies in the Y signal nearly as much. As a result, the images stay reasonably sharp. It's admittedly a bit more complex than the 'cheapo' adaptors, but it's still low in cost and very easy to build and get going.

How it works

The approach taken here to reduce cross-colour interference is to use a simple *LC* trap circuit to notch out a fairly narrow range of frequencies in the incoming luminance (Y) signal, centred on the 4.43361875MHz colour subcarrier frequency. This removes most of the higher luminance frequencies that cause obvious cross-colour patterning, while leaving the luminance frequencies below about 3.5MHz and above 5.4MHz untouched. You can see the resulting luminance response in Fig.2.

By contrast, the incoming chrominance signal passes through its channel largely untouched, so there's no degradation of colour detail. As a result, the image quality of the composite video output signal is quite good. Of course, it's not as good as watching S-video directly, but it's noticeably better than what you get with a 'cheapo' adaptor.

Circuit details

Now let's take a look at the circuit diagram for the video converter – see Fig.3. As shown, the incoming S-video (Y/C) signals come in via CON1, a standard 4-pin mini-DIN socket. The C signal is fed through a 220nF coupling capacitor and is terminated by a 75Ω resistor to prevent ringing due to cable reflections.

From there, the signal is fed to pin 5 of IC1b, one half of a MAX4451 dual-wideband video amplifier IC, wired here as a non-inverting amplifier with a gain of 2.0. This gain is necessary to allow for mixing and output cable back-termination losses.

The incoming Y signal is treated a little more harshly. After being terminated by the correct 75Ω impedance, it's then passed through the 'notch' circuit. This consists of a series 680Ω resistor and a series *LC*-tuned circuit, formed by a 68μH RF choke (RFC1) and a 6-30pF trimmer capacitor (VC1).

When VC1 is adjusted to resonate with RFC1 at 4.43361875MHz, this *LC* circuit forms a low-impedance path to earth at that frequency. This acts together with the 680Ω series resistor to produce the desired notch in the response, as shown in Fig.2.

From there, the rest of the Y signal is passed through IC1a, the other half of the MAX4451 device, which is also wired as a non-inverting amplifier with a gain of 2.0. The outputs of both IC1b and IC1a are then mixed using the two 75Ω output back-terminating resistors, to produce the final composite video output signal at output connector CON2.

Power supply

The MAX4451 IC needs a DC supply of ±5V and this is provided using the simple power supply circuit shown at the bottom of Fig.3.

Power comes from a 9V AC plugpack supply and this feeds two half-wave rectifiers based on diodes D1 and D2. Their outputs are filtered using two 470μF capacitors and fed to positive and negative 3-terminal

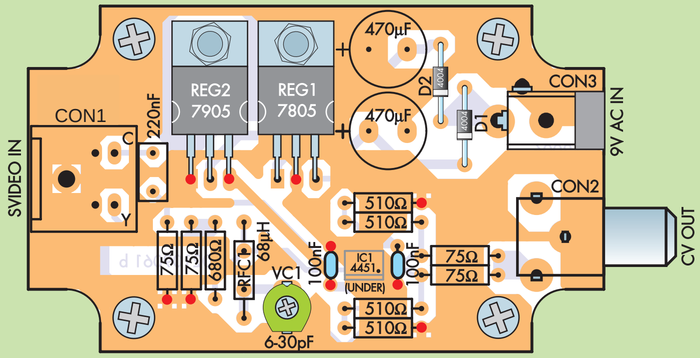
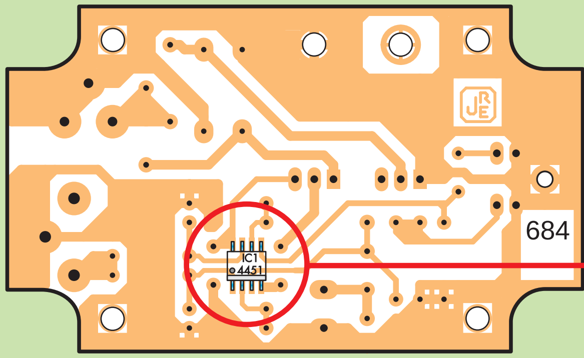


Fig.4: install the parts on the PC board as shown here, making sure that all polarised parts are correctly orientated. The leads designated with a red dot must be soldered to both sides of the board.



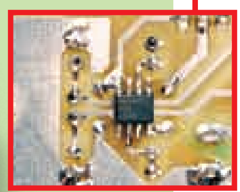
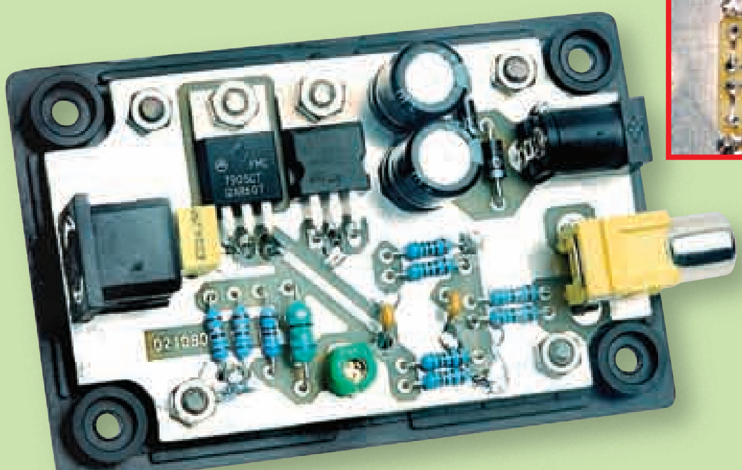


Fig.5: the MAX4451 comes in an SOIC-8 package and is mounted on the underside of the PC board as shown above and in the photo below right. Be sure to mount it with its chamfer side towards the bottom and use a soldering iron with a very fine chisel-tip to solder its leads.



This is the fully-assembled PC board, mounted on the lid of the case. Power comes from an external 9V AC plugpack.

Table 2: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	1	680Ω	blue grey brown brown	blue grey black black brown
❏	4	510Ω	green brown brown brown	green brown black black brown
❏	4	75Ω	violet green black brown	violet green black gold brown

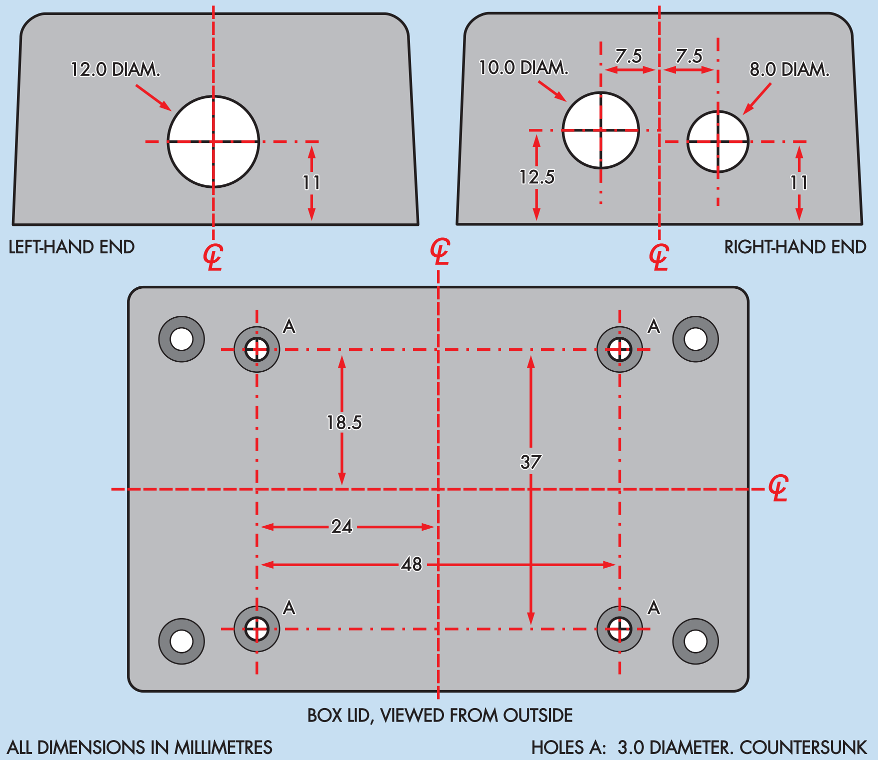


Fig.6: follow this diagram to mark out the holes to be drilled in the ends of the box and the box lid. Alternatively, you can scan this diagram, print it out and use it as a drilling template. The larger holes are best made by drilling a small hole first and then enlarging them using a tapered reamer.

voltage regulators REG1 and REG2. Regulator REG1 then provides the +5V rail, while REG2 provides the –5V rail.

Construction

All of the parts for the converter fit on a small double-sided PC board measuring 76 × 46mm. This board is available from the *EPE PCB Service*, code 684. Note, the board is not a 'plated through the hole' type. The topside component layout and the underside view, showing the MAX4451 IC positioning, is illustrated in Fig.4 and Fig.5.

The board has rounded cutouts in each corner, so it will fit snugly in to one of the small plastic UB5 type boxes. The S-video input socket CON1 is at one end of the board and box, while the composite video output and power sockets (CON2 and CON3) are at the other end.

Begin construction by checking the hole sizes for the three connectors and enlarge these if necessary. That done, start the assembly by installing the resistors and the capacitors. Note that the two 470µF electrolytic capacitors are polarised and must be fitted with their positive leads towards the left, as shown on the overlay diagram.

As the board is double-sided, you must solder the component leads to both sides of the PC board in those locations marked with a red dot on Fig.4. That way, the component leads themselves make the necessary connections between the two sides of the board.

Trimmer capacitor VC1 can go in next, noting that its flat side goes towards the bottom of the board. Follow this with the 68µH RF choke (RFC1) – the PC board can accept either an axial-lead or 'single-ended' choke, so use whichever set of holes is the most convenient for the part supplied.

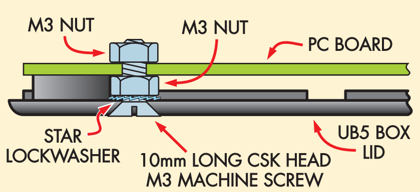


Fig.7: the PC board is mounted on the lid using M3 × 10mm machine screws, nuts and lockwashers.

Fit diodes D1 and D2, followed by regulators REG1 and REG2. The latter are both installed with their leads bent downwards by 90°, about 6mm from their bodies. Slip them into the positions indicated, then fasten their metal tabs to the PC board using M3 × 6mm machine screws and nuts before soldering their leads.

It's important not to solder the leads before the metal tabs are secured. If you do, the solder joints could fracture (or the copper tracks could lift) as the nuts are tightened. Take care to use the correct regulator type in each position (REG1 is a 7805 type, while REG2 is a 7905).

Surface mounting

Now for the dual video op amp (IC1). This comes in a very small SOIC-8 surface-mount package and is mounted on the underside of the board – see Fig.5. Note also that it's mounted with its chamfer and notch side towards the bottom edge of the board.

Because its leads are spaced just 1.25mm apart, you need to **take great care** when soldering them to the copper pads. Be sure to use a soldering iron with a very fine chisel-tip and make sure the tip is very clean.

Place the device and its leads carefully over the pads and hold it in place with a toothpick (or 'crossover' tweezers) while you just touch the tip of the iron to one lead for a second or two, to melt the solder underneath. This should be sufficient to hold the device in place while you solder all the other leads to complete the job.

The board assembly can now be completed by turning it back over and fitting the three connectors (CON1-CON3).

Final assembly

The PC board fits neatly into a UB5-size (83 × 53 × 31mm) plastic box, but first you have to drill the various holes in the box and its lid.

Fig.6 shows the locations and sizes of these holes. There are only seven holes in all: four in the lid for the PC board mounting screws and three larger holes in the box ends for the connectors.

Once these holes have been drilled, mount the PC board on the inside of the lid using four M3 × 10mm machine screws with countersink heads – see Fig.7. Note that each screw has an M3 star lockwasher fitted to it first, after which a nut is fitted and tightened to secure it in position.

In practice, these nuts act as spacers, which raise the PC board about 3mm from the lid (which is used here as the base). Once all the screws are in position, slip the PC board into place and secure it with the four remaining nuts.

Notch adjustment

The luminance notch trap can either be set visually or you can use an RF signal generator and an oscilloscope.

If you have access to the required test instruments, simply set the RF generator to 4.43361875MHz (use a frequency counter to do this if necessary) and feed its output into the Y signal input – ie, pin 3 of CON1 (or the junction of the 75Ω and 680Ω resistors). That done, use your scope to monitor the signal level at the composite video output of the converter (the centre pin of CON2) and adjust trimmer capacitor VC1 carefully until you see the signal level drop down into a sharp null.

The correct setting for VC1 is right at the bottom of that null.

Of course, you won't be able to set the notch frequency this accurately if you don't have access to test instruments. In that case, you'll have to set it visually, with the converter operating on a suitable S-video signal from your set-top box or a DVD player.

Try to pick a scene where there is some cross-colour patterning visible in the images. It's then just a matter of slowly and carefully adjusting VC1 with an alignment tool or jeweller's screwdriver until the cross-colour 'nasties' disappear.

Note that you may need to repeat this procedure a few times until you're confident that you've found the correct setting.

Finally, the box can be slipped over the lid assembly and secured using the small self-tapping screws provided. That's it – you're now ready to connect your set-top box or DVD player to your TV's composite video input via your new adaptor. ***EPE***

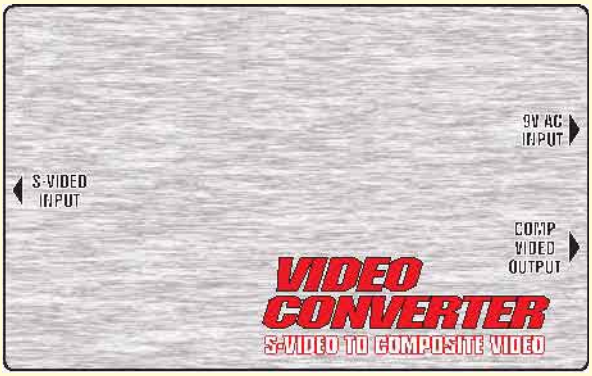


Fig.8: this full-size artwork can be cut out and attached to the lid of the case. A single layer of clear, wide adhesive tape will protect it from damage.

Practically Speaking

Robert Penfold looks at the Techniques of Actually Doing it!

HAVING completed a circuit board successfully it is tempting to sit back and regard the project as almost finished. With some projects this is probably a realistic view of things, but with others it is a bit like getting the lawnmower out of the shed and considering the lawn to be almost fully mown!

With many projects there is still a long way to go once the circuit board has been completed. The hard wiring and mechanical aspects of construction can be quite time consuming, but they should never be rushed.

Did it my way

Project articles invariably provide detailed instructions for building the circuit boards and completing the hard wiring, but are often fairly sketchy about the mechanical aspects of construction. Most constructors prefer to 'do their own thing' with this aspect of project construction, and this is reflected in project articles. There are exceptions, and with some of the more unusual projects it can be important for the original project to be cloned quite accurately, but in most cases there is plenty of freedom to 'do your own thing'.

A problem with going your own way is that the chances of making a mess of things are greatly increased. Careful planning is important when making anything, including relatively simple things. If you simply make it up as you go along, even with a fairly simple project, it will probably look as though the design was not properly thought through in advance.

You might even find that the finished project has a fatal flaw. The classic mistake is to forget about space for the battery. The finished project is perfect in every detail, apart from the fact that is not possible to fit the lid on the case unless the battery is removed!

Case study

The first task when designing the layout of a project is to select a suitable case. There are many different types of case available, but they can be categorised into two main sorts. These are the simple boxes, which are mostly made from plastic or from plastic with an aluminium lid, and instrument cases. The latter used to be made entirely from metal, but these days they are often in the form of a plastic shell with aluminium front and rear panels.

Instrument cases tend to be relatively expensive, but usually give a project a more classy appearance. Instrument cases are usually worth the extra outlay for larger projects or smaller projects where this type of case is appropriate, such as some types of test equipment.

It is usually all right to use any case that is large enough to accommodate everything properly, but it is a good idea to check the construction notes before buying anything. Plastic cases are unsuitable in some applications, while in others a metal case is unsuitable.

Some radio projects for example, have an internal aerial that will be shielded from the radio signals if a metal case is used. With other projects, such as sensitive audio circuits, it is the other way around. A metal case is needed in order to screen the electronics from radio waves and other sources of electrical interference. Always heed the advice when an article specifies a certain type of case. The project is unlikely to work if you go against this advice.

In these days of miniaturisation it is tempting to cram projects into the smallest possible housing, but it is also a mistake. The 'quart into a pint pot' approach to project construction makes building the projects much more difficult, and it does not necessarily produce a more usable end product. In fact, the opposite can apply, with the finished project being very fiddly and awkward to use. Going in the opposite direction is not a good idea either, as it could produce a cumbersome project in a case that is unnecessarily expensive.

So how do you work out whether a likely case will actually be just about right for your latest project? It is not just a matter of choosing a case that will accommodate all the components; it must be able to take everything using a sensible layout. The front panel layout might look quite good with several controls grouped very close together, but it will be of little practical use if it is virtually impossible to get at each control and operate it properly.

The finished unit needs to look reasonably neat, but it is usability that is of paramount importance. The case must be sufficiently large to permit a layout that has everything well positioned.

Fig.1. Clockwise from the top left, a large but simple plastic box, a simple folded aluminium box, a steel instrument case with an aluminium chassis, and a plastic instrument case that has an aluminium front panel

Ins and outs

You have to be careful when considering the sizes quoted for boxes and cases in component catalogues. Sometimes internal and external dimensions are quoted, and it is the internal size that governs the useful capacity of an enclosure.

Where only external dimensions are quoted, it is necessary to reduce them by about 5mm to 10mm in order to give an approximation of the internal size. There is a slight complication here, in that most cases have internal obstructions, and these can effectively reduce the internal dimensions of a case.

For instance, many cases have mounting pillars or guide-rails for printed circuit boards (PCBs). These might be useful for their intended purpose, but in practice they are often unnecessary and just get in the way. Many cases have threaded pillars to take the mounting bolts for the lid or outer cover. The mounting pillars for the lid are usually right in the corners, where they are unlikely to become major obstructions, but I have encountered instrument cases where they are positioned well in from the corners, often making their use problematic.

Some cases have internal mouldings that seem to serve no purpose whatever, and they are presumably needed as part of the manufacturing process.

Ideally, you need to see a case before buying it, so that a check for any major obstructions can be made. In practice, it will probably not be possible to do this, but illustrations in catalogues can help. Once again though, it is best to err on the side of caution and choose a case that has ample proportions rather than one where you are trusting to luck.

Some obstructions can be carefully removed if they cause major problems. For example, plastic mounting pillars for circuit boards can usually be drilled down to practically nothing. With this type of thing be careful not to overdo it and damage the case, or to remove anything that is actually an important part of the case.

Be careful when designing a layout for a project that uses a case having the outer cover held in place by long self-tapping screws. These penetrate well into the case when the outer cover is fitted in place, possibly with disastrous results if the interior layout has not been designed with due care.

Despite making careful measurements, mounting screws have damaged a battery on one occasion, and even a mains lead on another. Always allow an excess of space for anything like this, and with screws that are unreasonably large it is a good idea to replace them with shorter ones.

Direct approach

It is easy to draw up wonderful plans for a project that looks really good, but real-world design work tends to be about the balancing of conflicting requirements. Ideally, the controls and sockets would be positioned to give a neat and attractive layout, and nothing else would be taken into account. Unfortunately, such a layout might not be very practical. Layouts having long wires running all over the place are best avoided. This is not just a matter of avoiding lots of trailing wires because they look decidedly scrappy. It can be necessary to position controls and sockets where they permit short and neat wiring, rather than simply placing them wherever you like.

Often the wiring has to be kept quite short in order minimise problems with stray pick up of mains 'hum' and other signals, and to minimise stray feedback. Where appropriate, an article should point out any important restrictions on the layout, such as leads that have to be kept very short, and leads that should be kept well apart. With analogue circuits, it is generally advisable to keep inputs and outputs well separated, and to arrange the layout so that, as far as possible, the wiring can be kept short and direct.

Looks right

When drawing front panel layouts it is best to avoid taking an overly mathematical approach, but a haphazard approach to things is best avoided as well. Front panels usually look neater if there is equal spacing in a row of control knobs of the same size, and if everything is arranged in one or two rows rather than on several levels.

However, a purely mathematical approach to front panel layouts will not always produce the best looking results. The best looking layout is the one that actually looks best, and not the one that has the best geometry 'on paper'. A good way to try out layouts is to place the control knobs onto the front panel, together with fixing nuts to represent things like toggle switches or sockets. This gives a very good impression of the finished panel's appearance, and it also helps to avoid producing a 'paper' design that cannot be turned into a finished project due to a lack of space for certain components. It is still necessary to do some careful checking and measuring to ensure that there is room for everything. The components on the rear of the panel can be much larger than the control knobs and mounting nuts at the front. Remember to check that nothing fitted on the front panel will be blocked by any obstructions inside the case.

Fig.2. This plastic box has an uncluttered interior, but the printed circuit mounting rails moulded into the sides make it difficult to mount anything else on these panels

When everything looks just right and the checking process has been completed, make careful measurements and draw a plan of the layout. It does not matter whether the plan is drawn on a scrap of paper using a pencil stub or using the latest computer aided drawing program on a computer. What really matters is that it is clear, that nothing has been omitted, and that you can easily follow it when drilling and cutting the front panel of the case.

Marking out

It is a good idea to double-check the layout to make sure you have not overlooked anything, and then the layout can be transferred to the front panel. Take due care when doing this, as many project cases are made from soft plastics or aluminium. These materials have the advantage of being relatively easy to work, but they are also easily damaged. Mark the drilling points using something that will not scar the case for life, such as a fibre-tip pen.

Avoid using spirit-based inks on plastic panels, because the spirit in the ink might dissolve the plastic and permanently mark the panel. The suitability of a pen can be determined by trying it on an inner surface of the case or panel, where any damage will be of no importance. Very soft pencils (about 6B) mark aluminium panels reasonably well and should not cause any damage. An ordinary eraser can be used to remove the lines when the drilling and cutting have been completed. Inks that are not spirit based can usually be removed with a damp cloth or piece of kitchen towel.

An alternative approach is to fix a piece of paper over the front of the panel using double-sided adhesive tape or a Pritt-Stick glue pen. In other words, something that will hold the paper in place quite well temporarily, but is easily removed once the paper has served its purpose.

This method is very useful with some plastic panels, which seem to resist any form of ink. It works well with practically any case though, making it easy to mark the layout very accurately. Also, the paper gives some protection to the panel. The paper should peel off quite easily once work on the panel has been completed, and any remaining adhesive or paper is then washed off.

Softly, softly

I make no apology for repeating this warning to those who are experienced in general do-it-yourself tasks, car servicing, house extensions, and so on. With electronic project construction you are dealing with minute and often delicate components that require a more gentle approach. Applying the 'hammer and tongs' approach to delicate circuit boards and small plastic cases is likely to result in a great deal of time and materials being wasted. Most projects are housed in plastic or aluminium cases that are easily damaged. The vast majority of cases have finishes that are easily spoiled. Electronic project construction requires a 'softly, softly' approach.

Use a centre punch to mark the positions of holes in metal cases. The punch produces tiny indentations that guide the drill bit and make accurate drilling much easier. An automatic punch works well with aluminium panels. Take due care when using an ordinary punch with aluminium cases, as thin aluminium panels can buckle and distort quite easily.

Using centre punches with plastic cases is a bit risky, since some plastic cases are easily cracked, but an indentation is still needed to stop the drill bit from wandering. Probably the best method is to use a pointed tool such as a bradawl, using the smallest amount of pressure that will do the job properly.

It is then a matter of clamping the panel to the worktop, complete with a scrap piece of MDF or timber beneath the panel. This supports the panel so that there is less risk of it buckling and it also helps to give 'cleaner' holes. It will probably be necessary to use some pieces of cloth to prevent the clamps from marking the panel.

Due to the softness of the materials used for most cases, drill slowly and carefully. Drill holes using an electric drill set at a low speed, or use a hand drill. Proceed slowly and carefully, and you should end up with a first-class finished product.

Resurrect your old LPs and 78s . . .

Build this magnetic cartridge preamplifier

...and dub them onto CDs or MP3 files

Do you have an old turntable but no RIAA inputs on your preamplifier? If so, you need this preamplifier for playback and for converting the output to CD or MP3 format.

By JOHN CLARKE

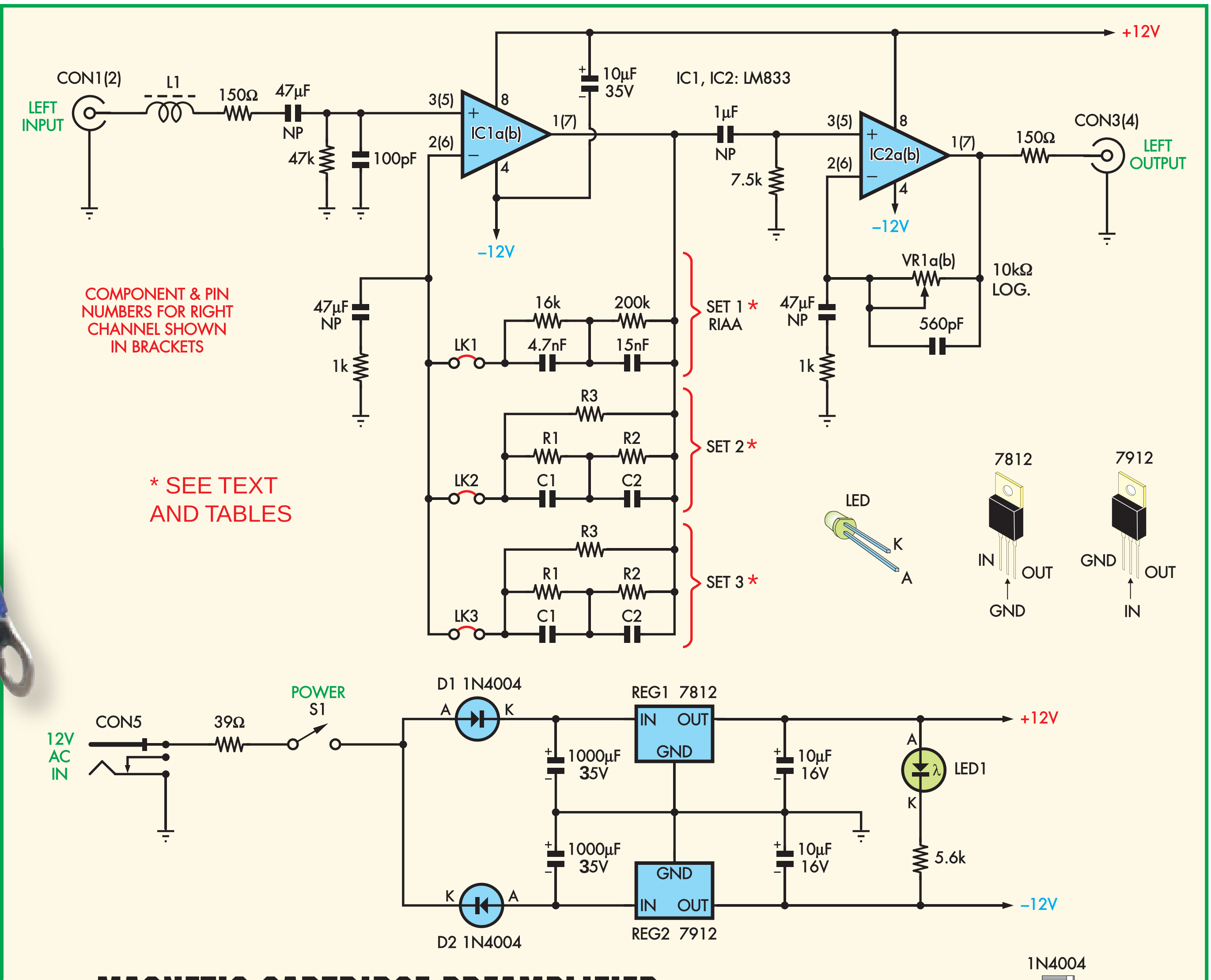
DO YOU HAVE a collection of old vinyl or 78 RPM records languishing in a cupboard? Perhaps you should resurrect them before they deteriorate further.

To do this, you need a computer with a CD or DVD burner, suitable software and a preamplifier. The preamplifier described here can be built to suit vinyl or 78 records, and is self-contained. You can build it into a diecast metal case or mount it underneath your turntable.

Of course, some people will just want to listen to their records without the bother of feeding signals into a computer and so on. This preamplifier will suit those people too, but ultimately, we think that anyone who has become used to the high-quality sound of compact discs or MP3 players will be disappointed with the clicks and pops and surface noise on LPs and 78s.

So, by all means build the preamplifier to play your old records, but you will probably end up going the whole way and dubbing your records to CD. In the process, you can filter out most of the clicks and noise and once again enjoy those old favourites.

If you only have vinyl records (LPs) you can build this project as a standard preamplifier with RIAA equalisation, but if you want to play 78s, you will need to choose one of three equalisation curves that can also be built in. You will also need a turntable that can play at 78 RPM and a cartridge that



MAGNETIC CARTRIDGE PREAMPLIFIER

Fig.1: the preamplifier circuit is based on two LM833 dual op amps (one channel only shown). It includes three sets of feedback networks (R1 to R3 and C1 to C2) and the values are chosen to give the equalisation required (see tables).

accepts the correct stylus. Ideally, the turntable should have speed adjustment so that the pitch can be changed, but this is a rare feature. Alternatively, commonly available recording software can adjust the pitch when you dub the records to CD.

The RIAA preamplifier is housed in a diecast metal box and has RCA phono sockets for the input and output connections. It has a control to set the output level and is powered using an AC plugpack.

Circuit description

The preamp circuitry is based on two LM833 dual op amp ICs, as shown in Fig.1. This shows the left channel only; the right channel is identical.

Some readers may wonder why we have used LM833 dual op amps instead of the newer high-performance OPA2134 devices featured in our recent *Studio Series Preamplifier* (Feb '08 to May '08). In fact, they could be used, but since the signal source is a magnetic cartridge playing vinyl or 78 RPM shellac records, any slight performance improvement will be negligible and is unlikely to be discerned by listening.

The input signal is fed through inductor L1, a 150Ω resistor and a 47µF

Specification

Signal-to-noise ratio: –84dB unweighted with respect to 10mV in and 560mV out (–89dB A-weighted)

Total harmonic distortion at 1kHz, 10mV in and 560mV out: 0.014%

Crosstalk: –79dB at 100Hz, –80dB at 1kHz and –70dB at 10kHz

Signal handling: 140mV before clipping

RIAA accuracy: typically within 1dB from 20Hz to 20kHz (see graph – Fig.2)

Parts List

1 PC board, *EPE* code 681, available from the *EPE PCB Service*, size 102 × 81mm
1 blank PC board, size 70 x 30mm (screening shield)
1 diecast box, 119 × 94 × 57mm
1 12V AC 250mA plugpack
1 SPST slimline toggle switch (S1)
2 dual RCA phono PC-mounting sockets (CON1 to CON4)
1 5-pin DIN PC-mount socket (optional)
1 2.5mm PC-mount DC socket
1 16mm dual-ganged 10kΩ log PC-mount potentiometer (VR1)
2 crimp eyelets
1 green banana socket
6 2-way 2.5mm pin headers (from a 12-way header strip)
2 2.5mm jumper plugs
2 ferrite beads 4mm OD x 1.5mm ID × 5mm (L1,L2)
4 10mm M3 tapped spacers
4 adhesive rubber feet
4 M3 × 6mm screws
2 M3 × 10mm screws
2 M3 nuts and star washers
2 No.8 self-tapping screws
7 PC stakes
1 150mm length of green hook-up wire
1 150mm length of red hook-up wire
1 150mm length of 0.7mm tinned copper wire

Semiconductors
2 LM833 dual op amps (IC1,IC2)
1 7812 +12V regulator (REG1)
1 7912 –12V regulator (REG2)
2 1N4004 1A diodes (D1,D2)
1 5mm red LED (LED1)

Capacitors
2 1000µF 35V PC electrolytic
6 47µF NP or BP non-polarised electrolytic
1 10µF 35V PC electrolytic
2 10µF 16V PC electrolytic
2 1µF NP or BP non-polarised electrolytic
2 560pF ceramic
2 100pF ceramic

Resistors (0.25W 1%)
2 47kΩ   4 150Ω
2 7.5kΩ   1 39Ω
4 1kΩ

RIAA components
2 200kΩ resistors
2 16kΩ resistors   SEE
2 15nF capacitors   TABLES
2 4.7nF capacitors

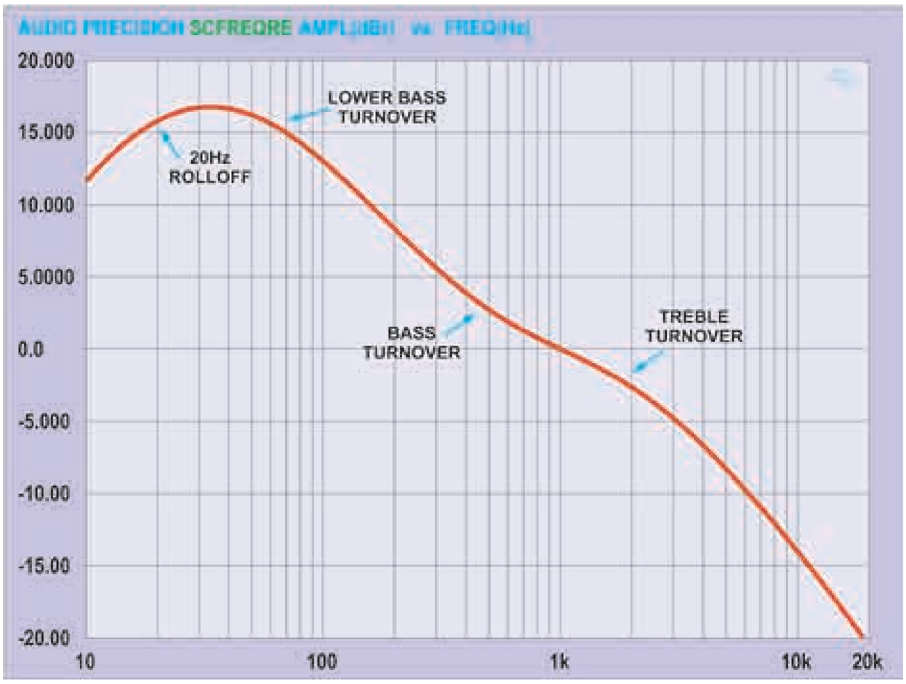


Fig.2: the RIAA response curve. The bass and treble turnover frequencies are set by the RC components in the feedback network connected to IC1a in the preamplifier.

capacitor to pin 3 of IC1a. The 47kΩ resistor and 100pF capacitor provide the loading for a typical magnetic cartridge. The 100pF capacitor also functions as an RF input filter, in conjunction with inductor L1 and the 150Ω resistor.

IC1a's gain is set by the feedback components between pin 1, pin 2 and ground. The 1kΩ resistor and 47µF non-polarised (NP) capacitor set the low-frequency roll-off for this stage at around 3Hz.

We have shown three sets of feedback components (C1, C2, R1, R2 and R3) and these can be selected to provide the RIAA or other equalisation responses for older recordings. The three sets of feedback components are labelled SET1, SET2 and SET3 and the particular equalisation SET is selected using jumper plug LK1, LK2 or LK3. The feedback components for the various equalisation curves are shown in Tables 2 and 4.

High-pass filter

IC1a's output appears at pin 1 and is fed to pin 3 of IC2a via a high-pass filter comprising a 1µF capacitor and a 7.5kΩ resistor. This filter rolls off signals below 20Hz to reduce rumble from the turntable. Signals above 20Hz

Why so many choices for equalisation?

Readers may be surprised to see the different equalisation curves for vinyl and 78 RPM records. It is not well-known these days, but before the recording industry standardised on the RIAA curves, the bigger recording companies had their own equalisation curves, hence there were curves such as Decca's 'ffrr' (full frequency range recording), as well as those for EMI, NARTB and Columbia.

The situation was even more chaotic before vinyl LPs came on the scene, and there was more choice (and confusion) with 78 records. Hence, some of the equalisation curves used included Decca (EMI) 78, Westrex and so on.

The reason for including these different sets of components in Tables 2 and 4 is so that if you can identify the company that made a particular recording, you can then select the appropriate equalisation characteristic.

Note that we have also shown values for flat frequency response (ie, no equalisation) and tape head equalisation.

Table 1: Microgroove 45 and LP frequencies					
Curve	Treble turnover	Bass turnover	Lower bass turnover	Cut at 10kHz	Boost at 50Hz
RIAA	2.1215kHz	500Hz	50.5Hz	-13.6dB	17dB
ffrr LP	3kHz	500Hz	100Hz	-10.5dB	12.5dB
EMI LP	2.5kHz	500Hz	70Hz	-12dB	14.5dB
NARTB	1.6kHz	500Hz	–	-16dB	16dB
Columbia	1.59kHz	500Hz	100Hz	-16dB	12.5dB

Table 2: Components for microgroove 45s and LPs					
Curve	R1	R2	C1	C2	R3
RIAA	16kΩ	200kΩ	4.7nF	15nF	–
ffrr LP	220kΩ	18kΩ	15nF	3.3nF	270kΩ
EMI LP	330kΩ	18kΩ	15nF	3.9nF	270kΩ
NARTB	2.2nF	18kΩ	18nF	5.6nF//390pF	270kΩ
Columbia	100kΩ	18kΩ	18nF//2.2nF	5.6nF//390pF	270kΩ

Table 3: Coarse groove 78 frequencies					
Curve	Treble turnover	Bass turnover	Lower bass turnover	Cut at 10kHz	Boost at 50Hz
Decca 78	3.4kHz	150Hz	–	-9dB	11dB
ffrr 78	6.36kHz	250Hz	40Hz	-5dB	12dB
Westrex	Flat	200Hz	–	–	15dB
Blumlein	Flat	250Hz	50Hz	–	12dB
BSI 78	3.18kHz	353Hz	50Hz	-10.5dB	14dB

Table 4: Components for coarse groove 78s					
Curve	R1	R2	C1	C2	R3
Decca 78	open	18kΩ	68nF	3.3nF	270kΩ
ffrr 78	220kΩ	18kΩ	33nF	1.5nF	270kΩ
Westrex	18nF	18kΩ	33nF	–	270kΩ
Blumlein	220kΩ	18kΩ	33nF	–	270kΩ
BSI 78	220kΩ	18kΩ	22nF	3.3nF	270kΩ

Table 5: Components for a flat response					
Gain	R1	R2	C1	C2	R3
x 1	open	1kΩ	–	4.7nF	–
x 10	link	10kΩ	–	470pF	–
x 100	link	100kΩ	–	47pF	–

Table 6: Components for tape head equalisation					
	R1	R2	C1	C2	R3
NAB	–	3.6kΩ	–	15nF	200kΩ

These tables show the components necessary to achieve the various response curves required to play back from vinyl records and other recording surfaces, including Shellac 78s and tape heads. The parts necessary to achieve a flat response (with various gains) for general purpose use are also shown.

are free to pass to the next stage of amplification within IC2a.

The gain of op amp IC2a is adjustable using potentiometer VR1. When VR1 is set fully anticlockwise, its resistance is zero and IC2a has a gain of one. Conversely, when the wiper is fully clockwise, VR1's resistance is 10kΩ and so the gain is 11. The 560pF capacitor across VR1 rolls off the gain at higher frequencies to prevent oscillation.

The outputs from IC2 are fed to the RCA phono sockets via 150Ω resistors, another measure to prevent oscillation because of the capacitance of the screened signal leads.

Power for the circuit comes from a 12V AC plugpack, which is fed to two diodes and two 1000µF capacitors to produce positive and negative supply rails. These are fed to 3-terminal voltage regulators (REG1, REG2) to derive ±12V DC rails.

Note that the plugpack feeds the two rectifier diodes (D1, D2) via a 39Ω resistor to limit the peak current into the 1000µF capacitors. This minimises any tendency for 100Hz rectifier buzz to become audible in the preamp's output signal.

The metal case of the preamp may be earthed if necessary, to avoid mains hum in the signal. In most cases, this will not be required.

Building the preamplifier

The preamplifier is built on a single-sided PC board, measuring 102 × 81mm. This board is available from the *EPE PCB Service*, code 681. It fits into a diecast box, size 119 × 94 × 57mm. Fig.3 shows the component layout and wiring details.

It's a good idea to first check the PC board for any defects, such as shorts between copper tracks, or for any breaks in the copper areas. Repair these if necessary and also check that the board has the correct hole sizes for components such as the dual RCA phono sockets, DC power socket and the dual-ganged potentiometer.

Begin the assembly by installing all the links, PC solder stakes and 2-pin headers. Before you insert the resistors, decide on the value of components you are going to use for each of the equalisation sets. **In most cases you will only use one set for the RIAA equalisation (the others can be left out).** Note that you need to place the same components in both the left and right channels for each set.

Table 7: Capacitor Codes

Value	µF Code	EIA Code	IEC Code
68nF	0.068µF	683	68n
33nF	0.033µF	333	33n
22nF	0.022µF	223	22n
18nF	0.018µF	183	18n
15nF	0.015µF	153	15n
4.7nF	0.0047µF	472	4n7
5.6nF	0.0056µF	562	5n6
3.9nF	0.0039µF	392	3n9
2.2nF	0.0022µF	222	2n2
1.5nF	0.0015µF	152	1n5
560pF	NA	561	560p
470pF	NA	471	470p
100pF	NA	101	100p
47pF	NA	47	47p

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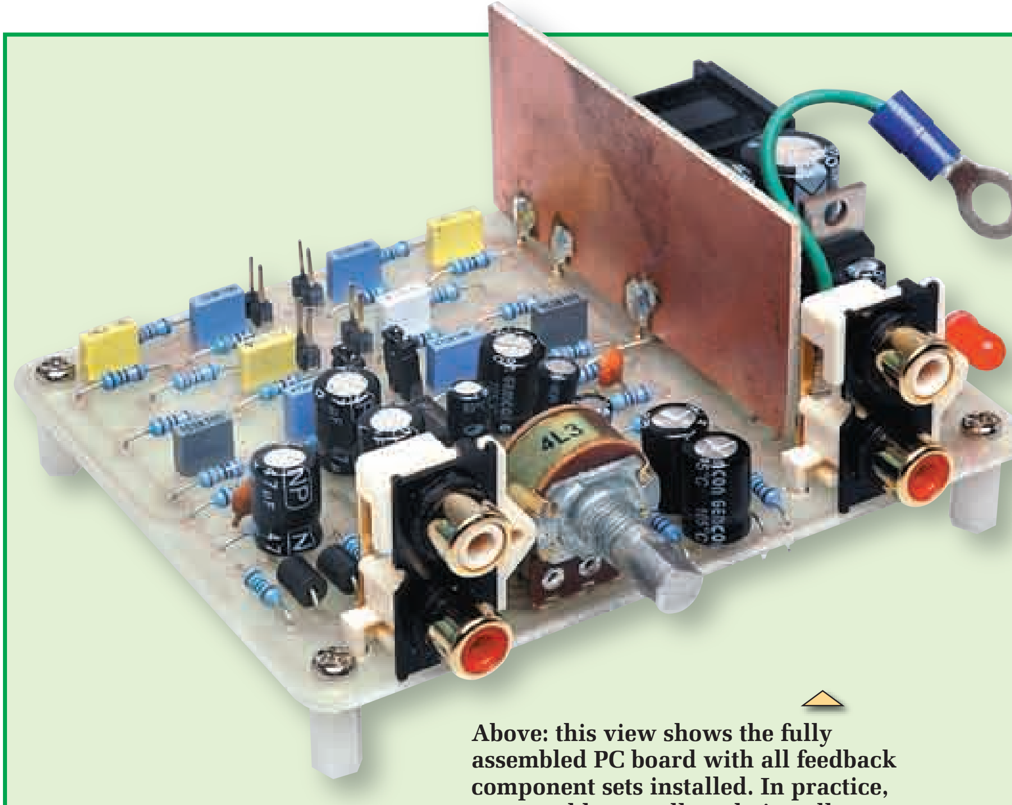


Above: this view shows the fully assembled PC board with all feedback component sets installed. In practice, you would normally only install one feedback set (typically for RIAA equalisation) and omit the parts for the other two sets.

The PC board is installed in the case by angling it (as shown here) so that the RCA phono sockets and the pot shaft go through their respective holes. It then sits on nylon spacers that are pre-fastened to the bottom of the case and it is secured using machine M3 × 6mm screws.

Install the resistors using the colour code table (Table 8) as a guide to finding the correct values. It's also a good idea to use a digital multimeter to make sure they are the correct values, as some of the colours can be difficult to decipher.

The two ferrite beads are mounted with short lengths of tinned copper wire passed through them.

The ICs can go in next, taking care to orient them correctly. Install the two diodes and the two voltage regulators, make sure the 7812 and the 7912 types are placed in their correct positions.

Next up are the capacitors. The polarised electrolytic types must be mounted with the correct polarity, as shown on the overlay diagram (Fig.3). Also, make sure you use the 35V 10µF capacitor adjacent to IC2. The NP (non-polarised) or BP (bipolar) electrolytic capacitors can be inserted either way around. Use Table 7 as a guide to selecting the non-electrolytic capacitors.

Next, mount the two dual RCA phono sockets, the potentiometer and

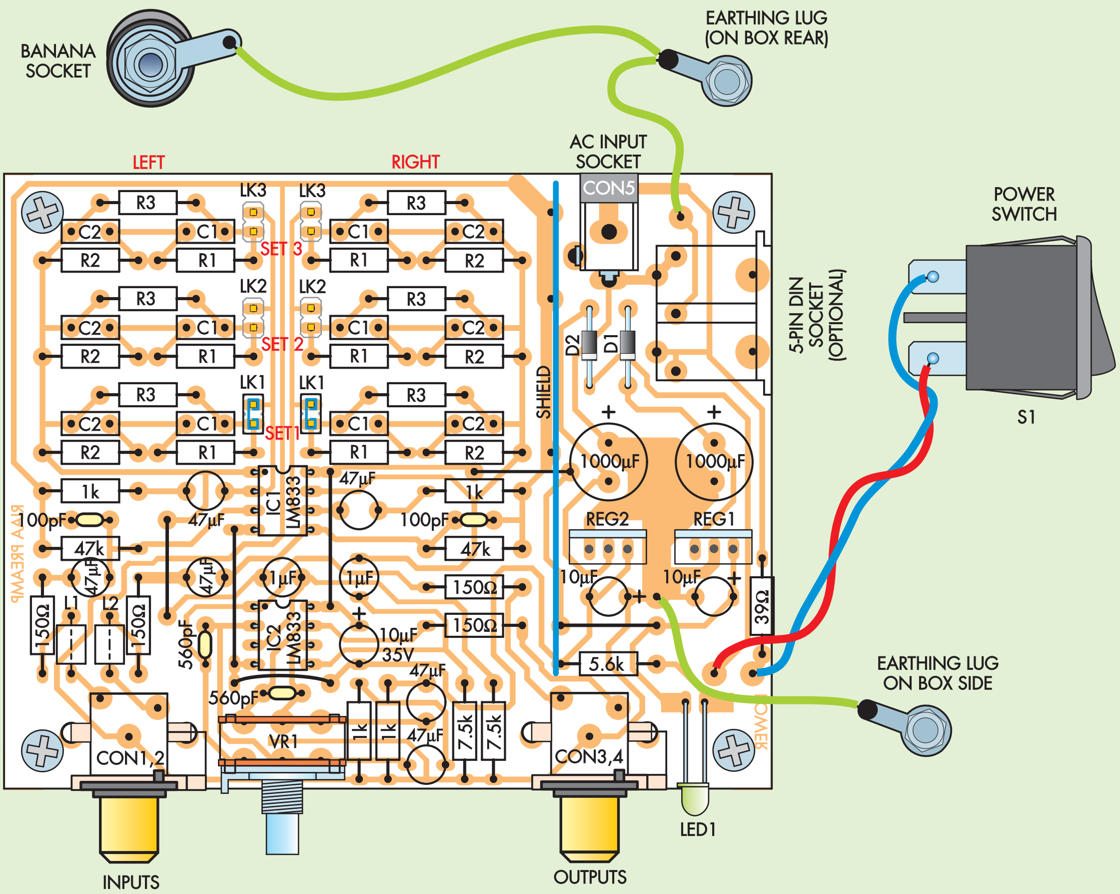


Fig.3: follow this parts layout and wiring diagram to build the preamplifier. Note that you can select only one set of feedback components at a time using either links LK1 or LK2 or LK3.

Table 8: Resistor Colour Codes

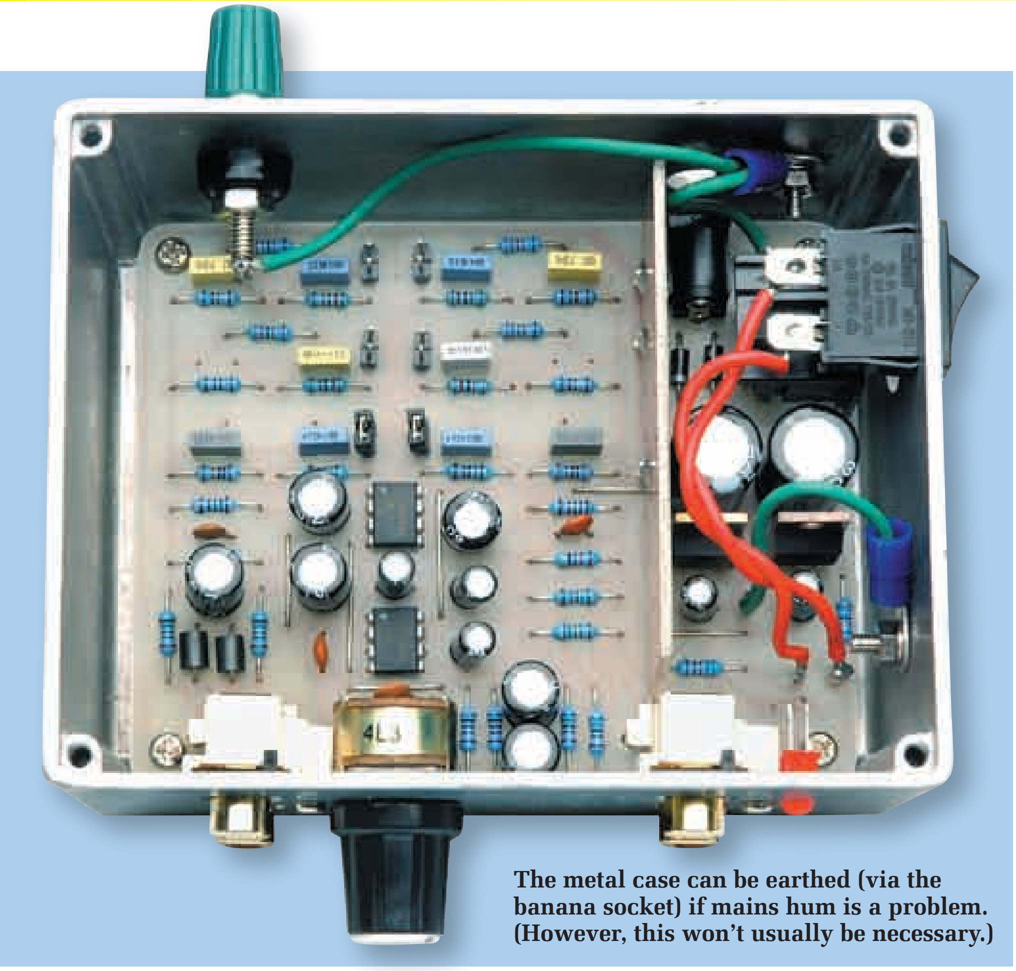
❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	330kΩ	orange orange yellow brown	orange orange black orange brown
❑	1	270kΩ	red violet yellow brown	red violet black orange brown
❑	1	220kΩ	red red yellow brown	red red black orange brown
❑	2	200kΩ	red black yellow brown	red black black orange brown
❑	1	100kΩ	brown black yellow brown	brown black black orange brown
❑	2	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	1	18kΩ	brown grey orange brown	brown grey black red brown
❑	2	16kΩ	brown blue orange brown	brown blue black red brown
❑	1	10kΩ	brown black orange brown	brown black black red brown
❑	2	7.5kΩ	violet green red brown	violet green black brown brown
❑	4	1kΩ	brown black red brown	brown black black brown brown
❑	4	150Ω	brown green brown brown	brown green black black brown
❑	1	39Ω	orange white black brown	orange white black gold brown

the DC socket. The optional 5-pin DIN socket can be installed later if you find that you need an earthed supply and there's no mains earth available (eg, an earthed metal case) to connect to the green banana socket.

The 'screening' shield consists of a piece of PC board, size 70 × 30mm, and is soldered to the PC stakes in the position shown. LED1 mounts high on its leads so it can be bent over and inserted into a hole in the side of the case.

Case work

The metal case will require drilling to accommodate the two stereo RCA phono sockets, the potentiometer and the LED on the front face of the case. On one side, holes are required for the



The metal case can be earthed (via the banana socket) if mains hum is a problem. (However, this won't usually be necessary.)

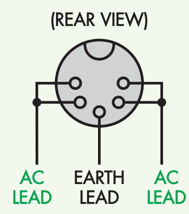


Fig.4: use the 5-pin DIN plug only if you need an earthed supply. The Jaycar MP-3022 earthed 17V AC plugpack can supply the required AC power and earth.

earth screw, the power switch and the DIN socket if used. At the rear, holes are required for the DC supply socket and the banana screw terminal/socket.

Mark and drill these holes. The slot required for the switch is best made by drilling about three holes within the cutout area and then filing it to shape. Four holes are also need to be drilled in the base for the plastic spacers for the PC board.

That done, attach the four rubber feet to the base of the case and then wire up the switches and earth connections as shown in Fig.3.

Testing

Connect power to the preamplifier and check that the LED lights when power is switched on. If it does not light, then perhaps the LED is installed the wrong way around.

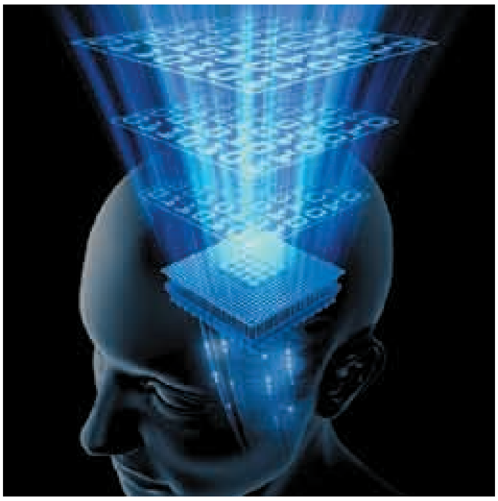
Next, measure the voltage between pins 4 and 8 of IC1 and IC2. It should be close to 24V DC in both cases. If this is correct, you are ready to connect a turntable and test the preamplifier.

Select RIAA equalisation for both the left and right channels using the jumper links, then connect the RCA phono leads from the turntable to the input sockets on the preamplifier. The RCA phono outputs on the preamplifier go to either a power amplifier or the line input of a computer using a 'Y' lead. The Y lead consists of a shielded stereo lead with RCA phono plugs at one end and a stereo 2.5mm jack plug at the other end.

If you are connecting the preamp to an amplifier, then plug in headphones or use loudspeakers.

If you are playing to a computer, then make sure the line input level is turned up. You can set this in Windows XP via Start/Settings/Control Panel/Sounds and Audio Devices/Audio, then select Volume in the Sound Recording section. *EPE*

Teach-In 2008



Part Eleven – Randomising values with PICs, plus a Fruit Machine!

JOHN BECKER

IN this final part of *Teach-In 2008*, we examine a concept that is of great benefit to many who write PIC programs for various games applications such as – randomisation.

There are many occasions when games need to periodically acquire values of a random nature, using those values to determine what happens at the next stage of the game. Such values need to be arrived at in a totally unpredictable manner, and minimise the risk of occuring in a repeatable fashion.

We showed in Part 3 a simple form of randomising for the Dice display, and in Part 8 for the Reaction Timing demo, yet another example was used in the Domino game last month. At the end of this part we give an example of a simple 'One-armed Bandit' or 'Fruit Machine' game that uses the more sophisicated technique described now.

Using discrete electronic components there are various ways of causing circuit responses to random events. Monitoring temperature, light or noise levels and deriving usable values from those is one way in which nature can produce a random trigger event. The problem there is that that the derived value will normally only fall within a very small range. There is also the consideration that the detection circuits can become complex, which is not compatible with the basic simplicity of a circuit that is microcontroller and software based.

Demo circuit

Throughout Part 11 we shall use, in whole or in part, the circuit shown in Fig.11.1. Its breadboard layout is shown in Fig.11.2.

The circuit in Fig.11.1 consists of the PIC16F628 connected to an LCD display. Switch S1 is the activating switch. Ignore the switch labelling for this demo. The PIC's internal 4MHz oscillator is used.

There are two demonstration programs, **TeachInY01.asm** and **TeachInY02.asm**. The former illustrates several methods by which random values can be generated. You select the relevant sections as instructed. The latter is the 'Fruit Machine', usable as a standalone program, but which you can also modify if you wish. It is discussed later.

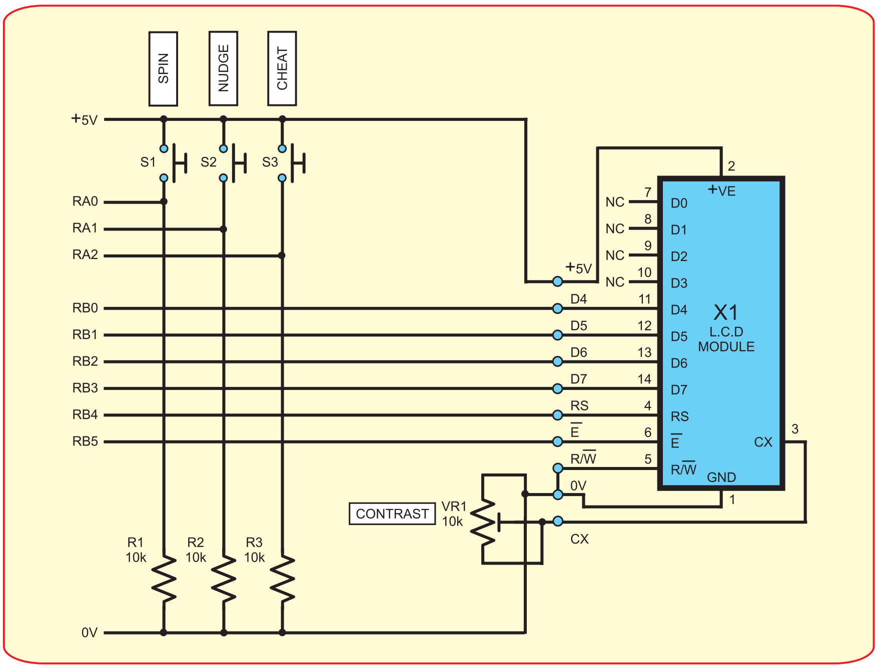


Fig.11.1 Circuit diagram for part 11 demos

The main control section for **TeachIn Y01.asm** is shown in Listing 11.1. The 'housekeeping' initialisation routines have been omitted, but are similar to those used in the previous *Teach-In 2008* demos.

Simple randomising

At the simplest level in a microcontroller design, random numbers can be obtained by the mere act of pressing a switch for a length of time determined by the user, incrementing a counter during the switch press, and then taking the value that exists at the end of the switch press.

Referring to Listing 11.1, switch S1 is monitored via PORTA,0. It is is normally biassed low and is repeatedly polled to see if it has been pressed:

```
MAIN     btfss PORTA,0
         goto MAIN
```

When it is pressed, there are several sub-routines which can be activated to illustrate how the switch press is handled. In Listing 11.1, it is the routine at BYTECOUNT255 which is accessed. You can select the other options by deleting the semicolon in front of the required 'call' statement, and inserting a

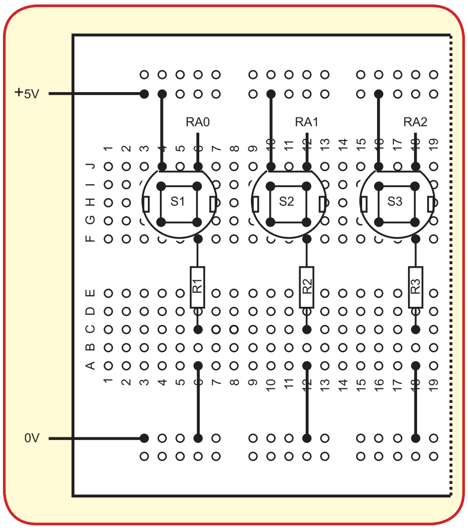


Fig.11.2. Breadboard layout for Fig.11.1

semicolon in front of the statement you no longer want. You then reassemble the code to a HEX file and program the PIC with it.

The routine for BYTECOUNT255 is shown in Listing 11.2.

When the switch is pressed, counter COUNTLSB increments at the rate at which the PIC is running (1MHz for a 4MHz oscillator) for as long as the switch is pressed.

When the switch is released, the binary count value in COUNTLSB is converted to a decimal format and output to the LCD. What you then do with this value is entirely up to you. Just jotting it down on a pad is probably all you may want to do at present, just so that you can compare the results of several switch presses in a sequence.

As things stand, it is the full value of the 1-byte counter, with a range of 0 to 255, which is shown, using the BIN2DEC and LCD control routines previously described.

Should you wish to slow down the incrementing rate, a delay routine may be called by removing the semicolon in front of **call PAUSIT**.

Value limitation

In a games situation, you may not want the random value to be displayed, in which case simply omit the display commands and make use of the derived value in any way you want.

If you require the random value to be limited to a maximum value below 255, this can be done in several ways. An example of limiting it to a maximum of 15 is shown in Listing 11.3.

Here, the limitation is done by the insertion of the command **andlw 15** (binary 00001111). Other AND values could be used instead, limiting the value to the maximum that can be held in the resulting active bits of COUNTLSB. A command of **andlw 7** (binary 00000111) would result in a maximum value of 7.

Of course, for a maximum value of 7, it is not necessary to use the BIN2DEC routine to convert the value for LCD display, as it is only necessary to OR the value with 48 to convert it for the LCD, as in Listing 11.4.

In this instance, it is also possible to keep the value below 8 by the inclusion of the command **bcf COUNTLSB,3** after **incf COUNTLSB,F**, as in Listing 11.5.

There are situations where you may want to limit the range to a value which cannot be obtained by ANDing or clearing bits. Such would be the case if you wished to create a value predictor for Lotto, where the maximum value is 49. An example of such limitation is shown in Listing 11.6.

Here the count value is constantly checked to see if it has gone beyond 49, ie to 50. If it has, the count value is reset to 0 at this point. Other values could be used instead, as appropriate to the situation.

There may be occasions when you want to arrive at values within a range greater than 255. Here the counter could use two or more bytes in the counting routine, as shown in Listing 11.7, which uses two bytes, COUNTLSB and COUNTMSB. Using two bytes produces a potential maximum of 65535. The routine could even be similarly extended to four bytes, an enormous value!

All the above routines make use of the length of time that the user keeps the switch pressed. You will also have noticed that the counter is never reset at the start of the switch being pressed. This helps to randomise the value produced. Randomisation is also helped by a phenomenon discussed in a previous part – byte values themselves can take on random values at the moment that a PIC is powered up.

Listing 11.1

```
MAIN          btfss PORTA,0
              goto MAIN
              call CLRLINE1
              call LCDMSG2

;             call BYTECOUNT7
;             call BYTECOUNT15
              call BYTECOUNT255
;             call BYTE2COUNT
;             call BYTECOUNT50
;             call BYTECOUNT7A
;             call RANDOMISE

              goto MAIN
```

Listing 11.2

```
BYTECOUNT255        incf COUNTLSB,F

;                   call PAUSIT

                    btfsc PORTA,0
                    goto BYTECOUNT255
                    call CLRLINE1
                    call LCD1
                    bsf RSLINE,4
                    movf COUNTLSB,W
                    movwf REGA0
                    clrf REGA1
                    clrf REGA2
                    clrf REGA3
                    call BIN2DEC
                    call SHOWDIGIT7
                    return
```

Listing 11.3

```
BYTECOUNT15         incf COUNTLSB,F
                    btfsc PORTA,0
                    goto BYTECOUNT15
                    call CLRLINE1
                    call LCD1
                    bsf RSLINE,4
                    movf COUNTLSB,W
                    andlw 15
                    movwf REGA0
                    clrf REGA1
                    lrf REGA2
                    clrf REGA3
                    call BIN2DEC
                    call SHOWDIGIT9
                    return
```

Automatic randomisation

There are situations, though, in which random numbers may need to be generated automatically throughout a program, without the intervention of user-pressed switches. There are several techniques which could be used, one of which is frequently encountered in purely hardware controlled designs – using shift registers and an XOR gate. The principle is shown in Fig.11.3.

Software can be used to simulate this technique. One way of doing it is shown in Listing 11.8.

In Listing 11.8, the equivalent of four 8-bit shift registers are used (RANDOM1 to RANDOM4), and two XOR gates (XORGATE1 and XORGATE2). The value within the RANDOM(x) bytes is repeatedlly rotated left each time the routine at SETRANDOM is called. Selected bits of two of the RANDOM(x) bytes are monitored, and if set, then bits within the XOR gates are also set.

The routine is too complicated to fully describe here, but the Carry flag of STATUS is rotated into the shift register on each rotate left. The Carry flag is also affected by the status of the XOR gates. As you have been been told, any left rotation of a byte also rotates the value of the Carry flag in at the 'right' of the rotated byte, and the status of the final bit of that byte is rotated back into Carry.

The result is that the values within the RANDOM(x) bytes change in a pseudo-random fashion each time the SETRANDOM routine is called. The value within any of the RANDOM(x) bytes can be used as the source of the required random value. That value can also be limited to a given maximum prior to it being used by the rest of the program, whatever that might be. Any of the techniques described above can be used to provide that limitation.

In the **TeachInY01.asm** demo program, select **call RANDOMISE** to see the random value generated each time the switch is pressed. The routine's details are shown in Listing 11.9.

Seeding

What may not be obvious is the fact that the value within the RANDOM(x) bytes at power-on could in fact be zero. This is a situation which can never generate a value other than zero. It is essential to ensure that this can never happen.

It is possible, of course, to check the RANDOM(x) bytes for all zeros following switch-on and setting at least one of them to a non-zero value. In a simple program, however, just setting a specified value into the bytes would itself be a non-random event. What is needed is a value which itself changes each time the power is switched on. Such a value is known as a 'seed'.

One way to do this is to have a value held within the PIC's non-volatile memory (EEPROM) which is retrieved at switch on, and then is immediately updated and stored back to the EEPROM as well as being set into RANDOM(x) bytes.

In the long term, there will indeed be repetition of seed values, but this technique does help to enhance the apparent randomisation of overall value generation. Remember that in software, we can only ever use pseudo-random value generation, but extending the repetition range is highly beneficial, reducing the chances of obvious predictability.

In Part 9 we illustrated how the PIC's EEPROM could be read and written to. That technique can be used in connection with acquiring and updating the seed value.

Any 8-bit value of the user's choosing could be set into the basic ASM program, with it automaticaly being set into the PIC via the HEX file. Each time the program is run, that value would be retrieved, used and updated, say incrementing it. It would be necessary, of course, to ensure that the updated value itself was never zero. But that's easy enough – if it is zero then increment it to 1.

That concludes this section looking at obtaining random values. Let's now look at a practical way in which randomisation is used.

Listing 11.4

```
BYTECOUNT7      incf COUNTLSB,F
                btfsc PORTA,0
                goto BYTECOUNT7
                call CLRLINE1
                call LCD1
                bsf RSLINE,4
                movf COUNTLSB,W
                andlw 7
                iorlw 48
                call LCDOUT
                return
```

Listing 11.5

```
BYTECOUNT7A     incf COUNTLSB,F
                bcf COUNTLSB,3
                btfsc PORTA,0
                goto BYTECOUNT7
                call CLRLINE1
                call LCD1
                bsf RSLINE,4
                movf COUNTLSB,W
                iorlw 48
                call LCDOUT
                return
```

Listing 11.6

```
BYTECOUNT50     incf COUNTLSB,F
                movf COUNTLSB,W
                xorlw 50
                btfsc STATUS,Z
                clrf COUNTLSB
                btfsc PORTA,0
                goto BYTECOUNT50
                call CLRLINE1
                call LCD1
                bsf RSLINE,4
                movf COUNTLSB,W
                movwf REGA0
                clrf REGA1
                clrf REGA2
                clrf REGA3
                call BIN2DEC
                call SHOWDIGIT9
                return
```

Fruity bandits ho!

Just for the sheer fun of it, we now present a program which is complete in its own right – the One-armed Bandit or Fruit Machine. You can enjoy using this on your own, or even to entertain your friends.

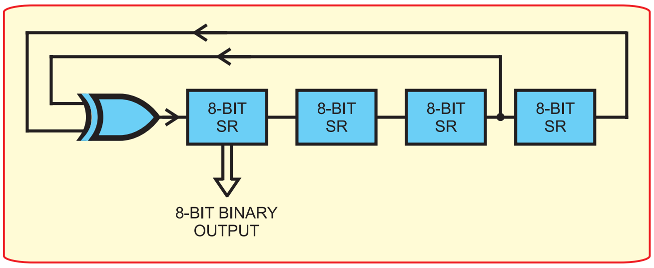


Fig.11.3. Shift register randomisation principle

The program uses the same circuit and breadboard layout as before, but now switches S2 and S3 are brought into use, named as S1 Spin, S2 Nudge and S3 Cheat! The program is in **TEACHINY02.asm**.

The program only roughly follows the typical structure of a real gaming machine of a similar nature. It effectively has three spinning wheels, represented by LCD display numbers that change at the top left of line 1. For simplicity, there is a cycle of four numbers for each wheel, 0 to 3, although this can be increased by the user if preferred, using one of the techniques described earlier.

At each press of the Spin switch, a jackpot value is incremented, representing the value that could be won when all three wheel values are identical. The 'wheel' numbers cycle through the three counters used, and are displayed on the LCD. They change so fast that the eye never sees the actual detail. When Spin is released, the counter values stop changing and their detail is shown.

The software immediately checks if all three displayed numbers are the same. If they are, the value of the jackpot is added to a total and the message WINNINGS xxx appears, where xxx represents the total won since the program was switched on. If it has been won, the next press of Spin clears the jackpot display, to restart from a value of 1.

If the jackpot has not been won, the numbers are checked to see if any two are the same. If they are, you can then push the Nudge switch to spin the wheel which has a value different to the other two. The spin continues for as long as the switch is pressed, again the value is displayed on the screen at a rapidly changing rate. On release of the switch, the cycling of the active counter ceases and the value now available can be seen. If the three values are now the same, you win the jackpot.

Nudge, nudge

If the jackpot has not been won the simple message NO LUCK THIS TIME! is shown and the jackpot and totals values remain unchanged.

Jackpot total scoring is affected not only by the value within the jackpot, but also by the value of the winning number, 1 for 1, 2 for 2, 3 for 3, and 10 for 0.

The Cheat switch allows you to always win the jackpot when the program provides the Nudge option. Pressing the switch always ensures that the 'wrong' number becomes the same as the other two, so ensuring a win. If you were to build this circuit on stripboard and house it in a box, you could have the Cheat switch on a lead external to the box and hidden somewhere. You could then press this switch unseen while pretending to press the Nudge switch, disguising from your friends that you are in fact cheating!

Possible changes

There are changes to the program that you might like to make. You could increase the number of values that are cycled through the counters, as described above. This will make it harder for a winning combination to occur (if you are not cheating!). The scoring values at any win could also be increased quite readily. The incremental value of the jackpot can also be changed to a higher value with a spot of minor program modification.

You could also allocate symbols other than the counter values themselves to be shown. For example, via a look-up table, you could allocate alphabet letters to be shown instead of the numerals. In Part 10 last month we also showed how you can create your own LCD symbols for display in place of the actual numerals.

Be adventurous, have a go at changing this program to suit your own needs. What you do and how you achieve it is entirely over to you – good luck!

PIC name again

That really ends this *Teach-In 2008* series, but one final point is worth making.

Since the series started, it has come to light that Wikipedia (**http://en.wikipedia.org/wiki/PIC_microcontroller**) states that:

The original PIC was built to be used with GI's (General Instrument) new 16-bit CPU, the CP1600. While generally a good CPU, the CP1600 had poor I/O performance, and the 8-bit PIC was developed in 1975 to improve performance of the overall system by off-loading I/O tasks from the CPU. The PIC used simple microcode stored in ROM to perform its tasks, and although the term wasn't used at the time, it shares some common features with RISC designs.

In 1985, GI spun off their microelectronics division, and the new ownership cancelled almost everything – which by this time was mostly out-of-date. The PIC, however, was upgraded with EPROM to produce a programmable channel controller.

Microchip Technology does not use PIC as an acronym; in fact the brand name is PICmicro. *It is generally regarded that PIC stands for* Peripheral Interface Controller, *although GI's original acronym for the initial PIC1640 and PIC1650 devices was* Programmable Interface Controller. *The acronym was quickly replaced with* Programmable Intelligent Computer.

Further reference

So, now over to you – enjoy using your PICs and the programs you write for them. And don't forget to read *PIC 'n Mix,* the regular column in *EPE*, which covers many aspects relating to PICs.

Listing 11.7

```
BYTE2COUNT      incfsz COUNTLSB,F
                goto BYTE2
                incf COUNTMSB,F

BYTE2           btfsc PORTA,0
                goto BYTE2COUNT
                call CLRLINE1
                call LCD1
                bsf RSLINE,4
                movf COUNTLSB,W
                movwf REGA0
                movf COUNTMSB,W
                movwf REGA1
                clrf REGA2
                clrf REGA3
                call BIN2DEC
                call SHOWDIGIT6
                return
```

Listing 11.8

```
SETRANDOM       clrf XORGATE1
                clrf XORGATE2
                btfsc RANDOM1,2
                bsf XORGATE1,0
                btfsc RANDOM4,6
                bsf XORGATE2,0
                bcf STATUS,C
                movf XORGATE1,W
                xorwf XORGATE2,W
                btfsc STATUS,Z
                bsf STATUS,C
                rrf RANDOM1,F
                rrf RANDOM2,F
                rrf RANDOM3,F
                rrf RANDOM4,F
                return
```

Listing 11.9

```
RANDOMISE       call SETRANDOM
                call LCD1
                bsf RSLINE,4
                movf RANDOM1,W
                movwf REGA0
                movf RANDOM2,W
                movwf REGA1
                movf RANDOM3,W
                movwf REGA2
                movf RANDOM4,W
                movwf REGA3
                call BIN2DEC
                call SHOWDIGIT1
                return
```

PIC32 Starter Kit Review

by Mike Hibbett

Microchip's newest processor – not one for beginners

Despite their line up of hundreds of PIC device variants, it's not often that Microchip introduces a completely new range of processors. In November 2007, however, that's exactly what happened. Microchip introduced the PIC32 family of 32-bit processors. There are currently ten variants available, with another seven on the horizon (which, most importantly, will add USB support to the family.)

THE PIC32 is significantly different from any previous processor available from Microchip. In fact, it's not even a Microchip processor – it's a MIPS32 M4K processor, licensed from a company called MIPS. MIPS created the M4K processor as a design specification, and licensed it out to companies who then add it into their own chips – as Microchip have done in this case.

If you would like to understand the background of this processor, take a look at **www.mips.com**

PIC32 features

The most interesting aspect of the PIC32 is its CPU databus size – 32 bits. This means that the processor can deal with very large numbers in a single instruction, making it very fast. Not only this, but it runs at 80MHz – twice the speed of the PIC18 family, enabling it to perform functions that no other PIC processor has been able to do before – such as MP3 decoding for example.

The new PIC32 parts introduce, for the first time, *USB OTG ports*. OTG means 'On The Go', referring to a mode which enables the processor to act as a USB host device. This means that a PIC project could connect to and control another USB device, such as a web camera, with suitable software. This is a feature engineers have been crying out for, so we should see some interesting applications created with these new processors!

And, of course, being Microchip products, these devices are available through the usual hobbyist-friendly suppliers such as Farnell, RS Components and Digikey.

On the downside – and this is what will make the parts difficult for hobbyists to use – the devices are only supplied in small pitched, flat surface-mount packages with a lead spacing of 0.5mm. Unless you are highly experienced with SMD soldering techniques, these parts are virtually unsolderable and, therefore, are going to be difficult to build into your own design. We see a blossoming market for third party suppliers to produce small PCBs with the processor fitted to it and tracks out to standard 0.1 inch header holes.

Another issue that is going to put off many hobbyists will be the fact that the PIC32 is an extremely complex processor – far more complex than any of the previous processors from Microchip. This is a serious processor, for serious work. It is designed to be programmed in C, and coupled with a high level operating system or RTOS.

On the other hand, this will be a wonderful device to push your assembly programming skills to the next level, if you like a challenge! A link to the datasheet for the processor can be found at the end of this article.

Starter kit

To help users become familiar with the device, Microchip has produced a small, low-cost product called the PIC32 Starter Kit, which we will be looking at in this article.

The starter kit contains a small PCB holding a PIC32 processor, a USB debug interface, some LEDs, switches and a connector for attaching the board to expansion modules (that you will no doubt be able to buy from Microchip or third parties). The USB interface is only for programming the PIC32 – it connects to a PIC18F4550, which acts like a PicKit2 programmer unit located on the PCB itself. The PIC32 device on

the starter kit has no USB functionality unfortunately, so you will not be able to make use of the interface in your applications.

Supplied with the board is a USB cable and a CD with tutorials and development tools. The board is powered directly by the USB cable, so you have everything you need to write, debug and test software on 'real' hardware. The photo below shows the full kit contents.

Software installation

As with all USB devices, it is important to install the software first before plugging the hardware into a USB port on your PC. If you don't, then the PC will not recognise the USB interface on the PIC32 board, and will disable access to it. So we left the PCB to one side, popped in the CD and followed the on-screen instructions.

Immediately we hit a problem. A pretty installation screen appeared, prompting 'Click to install from CD'. When this was clicked the Firefox web browser popped up, displayed a blank screen and nothing further happened.

Closing the web browser revealed the problem – displayed at the bottom of the installation menu is the text 'Firefox users: Navigate to the CD root directory and launch /fscommand/pic32_sk_installer.exe'.

They have gone to the (excessive) trouble of using flashy graphics and a web browser to install the software, but not provided support for the second most popular web browser in use. Where is the logic in that? Fortunately, installation from the fall-back installer worked perfectly.

Supplied software

The installation process loads the MPLAB IDE v8.0 onto your hard drive, and adds the MPLAB C32 compiler and MPLAB ASM32 assembler, both developed specifically for the PIC32 processor. The installed files can be found under *C:\program files\Microchip*. It's also worth taking a look through the newly installed directories, making a note of documentation found in .pdf and .txt files.

Several example projects are included to help you get started, and one in particular, located in *C:\Program Files\Microchip\pic32_solutions\pic32mx_starter_kit\sample_code\StarterKitTutorial*, has an accompanying multimedia tutorial, which can be found in: *C:\Program Files\Microchip\pic32_solutions\pic32mx_starter_kit\getting_started_flash_tutorial*.

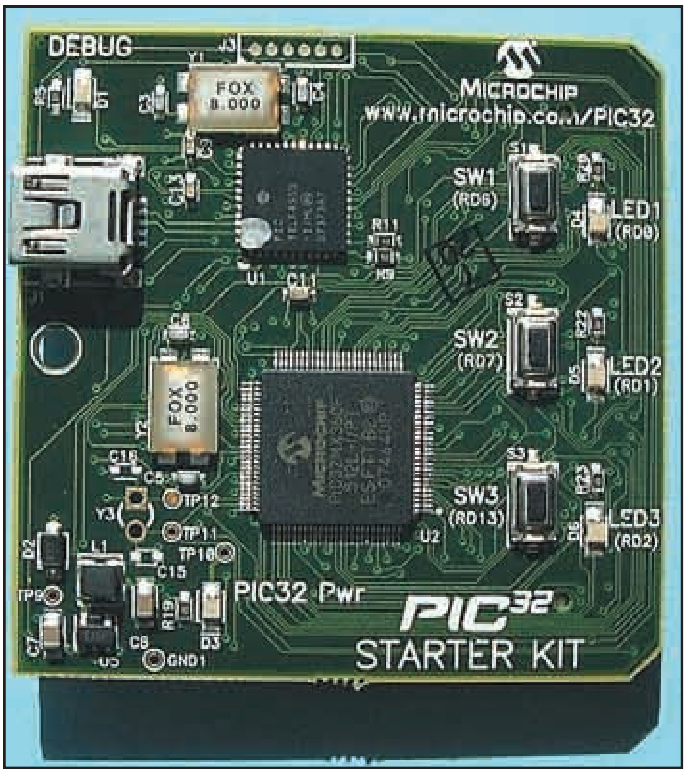
This is an excellent tutorial for those who are completely new to using MPLAB, and gives a starting point for editing and building new software within a few minutes. For those who are new to MPLAB, refer to the series of articles on MPLAB that we presented in the magazine in the June to September 2007 issues. They will help flesh out the details.

Having installed the software from the CD, you should immediately go and check for any new updates to the software on the Microchip website. At the time of writing MPLAB has progressed to v8.10, and as this is a new processor from Microchip, it is well worth making sure you are current with their development tools. Ensure you check for updates to the C32 compiler and ASM32 assembler program too.

For some strange reason no processor datasheet is included on the CD, so you will certainly want to download that from the Microchip website. See the references at the end of the article for its location.

Alternative software

While the MPLAB development environment supplied on the CD is a full and free product, the C compiler MPLAB C32 is not. It is limited to programs no greater than 64KB in



Topside view of PCB

Underside view of PCB

size, which may become a serious limitation when you consider that the PIC32 device has a massive 512KB of flash memory!

The full C32 compiler can be purchased, of course, but it costs several hundred pounds which may be an issue for hobbyists. Fortunately, several groups of engineers have announced on the Internet that they are working on producing an unrestricted compiler suite for the PIC32 – we will announce progress as it happens. (MPLAB C32 is itself based on GCC, a free open source compiler. The C libraries for PICC32 however are not part of GCC, and the 'free' compiler is useless without a library. It's the library that people are working on creating.)

Hardware

The two sides of the starter kit board are shown above. It's a compact little board, and is very portable with its DVD style case. Handy for shuffling between work and home.

Unlike the PicKit2 Demo board, which comes with a small prototyping area and 0.1 inch pitch holes for all I/O signals, the PIC32 starter kit board is equipped with three pushbutton switches and three LEDs. No UART access, no I/O pins, no solder pads or holes. Only a specialised 120-pin connector on the rear for expansion.

So to get any form of circuitry connected up to the processor you will need to find the matching connector and build an expansion board. Once again, however, we hit a problem – the connector pins are on a very fine pitch (0.5mm, again) and present the same soldering challenges as the processor itself. Once again, expect third party companies to start selling expansion PCBs to solve this problem.

Microchip produce their own range of expansion boards that mate with the starter kit PCB. The PIC32 I/O Expansion Board DM320002 brings the processor signals out to a variety of connectors and headers, but it isn't cheap – it adds another £36 to the cost of getting a development system together.

Alternatively, the MA320002 board is a small PCB fitted with just the processor that brings the processor pins out to standard 0.1 inch pitch header strips – a lot easier to work with, but you will need to provide your own programming interface connections. These are relatively cheap – £12 from RS Components, compared to £25 for the starter kit.

Unless you are in a hurry to get a system up and running, we would suggest the MA320002 board is the way to go – unless you are happy to solder 0.5mm lead pitch packages, in which case you can hand solder the PIC32 to your own PCB. Good luck with that though, it takes considerable skill!

The final option for getting to the I/O is to obtain a mating connector, and build your own expansion board. The part required is manufactured by Hirose, part number CL570-0203 or FX10A-120S/12-SV(71). It's available from Digikey.

Overall, we were initially disappointed with the PIC32 starter kit, since by itself, with its limited I/O capabilities, it doesn't provide much more than a software simulator – not very exciting. But it's still a good starting point for the adventure of learning to program the device, an adventure which is a considerable challenge. But for some projects, however, the challenge may well be worth the effort!

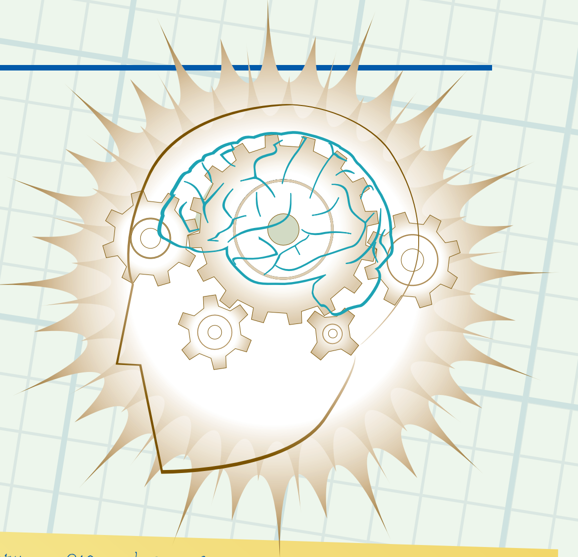
References

Hirose connector datasheet: **www.hirose.co.jp/cataloge_hp/e57000028.pdf**

PIC32 Datasheet: **www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=260**

Ingenuity Unlimited

Our regular round-up of readers' own circuits



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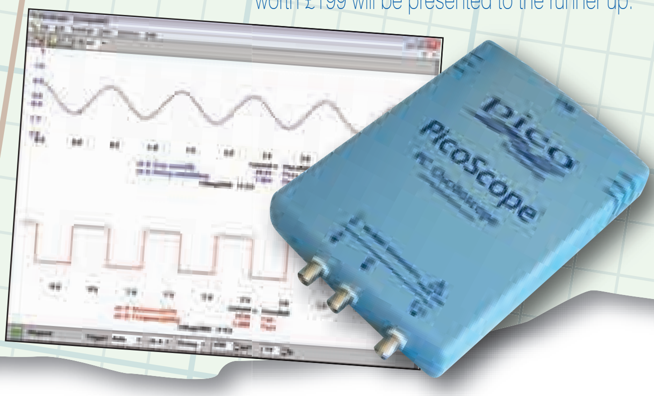

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Noise Generator – *The other side of golden?*

USUALLY, the aim of component manufacturers is to eliminate noise from their components. Thus, as electronics technology has advanced, so has noise in components become scarce. In the 1960s and 70s there still were quite a few noisy components around – which are now hard to find. Here, though, is a 'genuine noise' circuit built of components which should hopefully be readily available.

But first, why make noise? Here are a few examples of its uses. It may be useful for simulating 'chaotic' sounds such as 'ocean surf', or 'rushing wind'. Or it may be useful for injecting a genuinely random signal into a circuit. The author has found it useful for 'busting through' frequency lock in metal detector designs by injecting it into the 'zero beat frequency' zone of such a circuit, thus improving sensitivity.

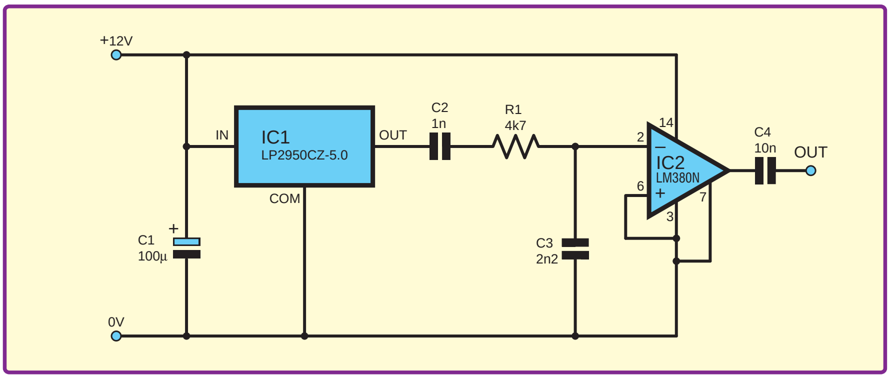

Fig.1. Circuit diagram for the simple Noise Generator

Noise circuit

In this circuit (Fig.1), noise is generated by IC1, a 5V micropower regulator. Capacitor C1 stabilises the noise source, IC1. C2 is a DC-blocking capacitor, while R1 and C3 form a 15kHz low-pass filter, with a frequency calculated by the formula $f = 1 / (2\pi \text{ R1 C3})$.

The low-pass filter is essential to prevent the high frequency component of the noise from overheating amplifier IC2. With the filter in place, about 80mV noise is generated. Without it, an excessive 500mV is generated. Capacitor C4 is both a DC-blocking capacitor, and provides further protection for IC2 from overheating.

Not every preamplifier or amplifier will serve the purpose in combination with IC1. That is, IC2 cannot simply be substituted for any preamplifier or amplifier. An example of a suitable substitute is the CMOS 4069 hex inverter, which fits the bill when wired as a high gain preamplifier. The circuit draws about 13mA at 12V.

Thomas Scarborough, Cape Town, South Africa

INGENUITY UNLIMITED

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IU is your forum where you can offer other readers the benefit of your Ingenuity. Share those ideas, earn some cash and possibly a prize.

LED brightness and switching inductive loads

Recently, ***Jimkirk*** posted details of one of his circuits on the *EPE* Chat Zone (via **www.epemag.wimborne.co.uk**). The circuit uses a phototransistor to switch a relay via another bipolar transistor. His circuit was not working, but at the time of writing it is not entirely clear why; it could be, for example, due to faulty components, the wrong type of components (eg relay specification), or insufficient gain in the switching transistor. However, one definite problem was noted by user Ant – the relay did not have a 'protection' diode connected across it. Also, on this topic is an earlier post from ***Echase***:

If you switch a relay, motor or other inductive load with a bipolar transistor, it is usual to connect a diode in reverse across the load to absorb the switch off spike, to stop it damaging the transistor… If you use a MOSFET it usually (always?) has an internal reversed diode across the drain and source junctions. Does this diode provide the same function as the above diode, even though it's not in the same position in the circuit, meaning that the above is not now needed?

We will look at the topic of switching inductive loads later in this article. First, we will consider a question posted by ***Techno*** on the Chat Zone. He asks:

I am connecting 10 white LEDs in parallel – I want to use a 24V DC supply. What value resistor must I use so that I can get the LEDs as bright as possible without damaging them?

The first point we have to make is that connecting the LEDs in parallel is not a good idea. This is because it will lead to possible variation in brightness between LEDs and may also lead to excessive power consumption in the resistors used to set the LED current. We will look in detail at why this is, and suggest a better approach, before returning to look at inductive load switching.

LED brightness

It is the *current* through an LED, not the voltage across it, which determines its brightness. Two individual LEDs of exactly the same type will produce the same illumination with the same forward current (I_F), but may have different forward voltage drops (V_F) at this current.

The variation in voltage drop between individual devices may be in the range 0.1 to 0.3V for typical 'ordinary' coloured LEDs. For high power and white LEDs the range may be much larger. This is a key fact that needs to be considered when designing LED drive circuits. This is illustrated in Fig.1, which shows possible forward characteristics for two LEDs of the same type.

Two LEDs driven in parallel, using a single current limiting resistor, is shown in Fig.2. This circuit forces the LEDs to have the same forward voltage drop, which means that their forward currents and hence brightness may be very different (see Fig.1).

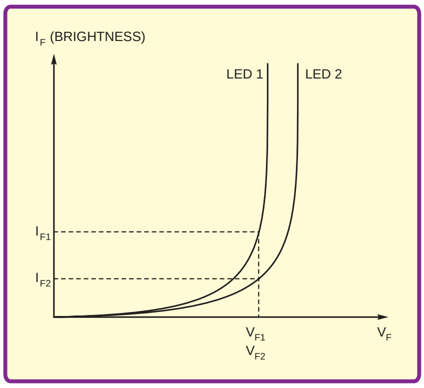

Fig.1. With the same forward voltage the LEDs may have different forward currents and hence different brightnesses.

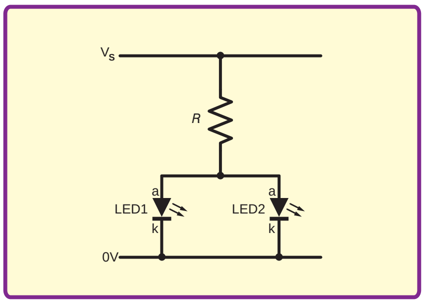

Fig.2. Driving two LEDs in parallel

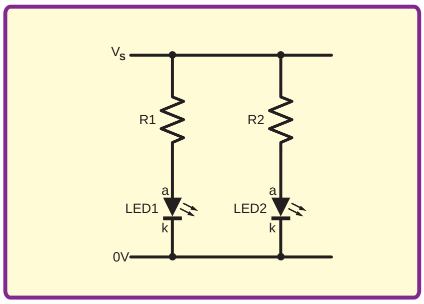

Fig.3. Two LEDs with separate current-limiting resistors

Fig.3 shows two LEDs with separate current-limiting resistors. However, we can still get problems with variation between individual devices resulting in varying brightness. An example will help explain this.

Assume we have white LEDs with LED1 having a forward voltage drop of 3.6V at a forward current of 20mA. If the supply (V_S) is 5V, we have R1 = 70Ω so that R1 drops 1.7V and we have 3.6V across LED1. If LED2 is also connected with R2 = 70Ω, but has, say, a forward voltage drop of 4.0V (due to variations in individual device characteristics), then the current in LED2 will be 14.3mA. The difference in current may show up as a noticeable difference in brightness.

If we use a higher supply voltage, the brightness variation problem is reduced. For example, consider a 24V supply. Lets say we have R1 = 1kΩ to get about 20mA (20.4mA) with a 3.6V drop across LED1 so that the LED is driven as before. Now consider LED2 with a 4.0V drop again and R2 = 1kΩ. The current in LED2 is 20.0mA, almost the same as LED1, so they should appear equally bright.

This comes at a high price though – the total power dissipation in the two current limiting resistors is about 0.8W in the second example, which is almost twenty times higher than in the first example. The second circuit is very inefficient and would not be very suitable for battery powered operation.

In series

The circuit in Fig.4 shows three LEDs driven in series. The current through the LEDs must be equal so their brightness will be equal.

A potential difficulty with this circuit is that a relatively high voltage is required to drive the series chain. For 10 white LEDs we would typically need about 30V to 45V depending on the forward voltage drop. In any case, more than the 24V supply that Techno wants to use. White LEDs have typical forward voltage drops ranging from about 3V to about 4.5V, depending on the type of LED used, although lower drops may occur for individual devices or if relatively low currents (and hence brightness levels) are used.

For a large number of LEDs, a compromise between parallel and series connection can reduce the need for a large supply voltage. This is illustrated by Fig.5, where 10 LEDs are connected in two groups of five in series. This would be suitable for driving the 10 LEDs from a 24V supply, as we would expect the groups

of five LEDs to have a total voltage drop in the range 15V to 23V. The choice of *R* depends on the expected forward voltage drop V_F at the current used I_F, which could be obtained from the manufacturer's datasheet or by measurement if you already have the devices.

The value of *R* is calculated using Ohm's law, using the LED current and the difference between the total LED drop and the supply. Thus, for Fig.5, $R = (V_S - 5V_F) / I_F$. For $V_S = 24V$, $V_F = 3.6$ and $I_F = 20mA$ we get $R = 300\Omega$, with a power dissipation of 180mW in the resistors (Power = I^2R).

Maximum brightness

To respond to the final part of Techno's question, that of achieving maximum brightness, the answer has to be 'read the datasheet'. This will provide information on the maximum forward current and hence maximum brightness levels.

The maximum current will depend on ambient temperature and will decrease at high temperatures (eg above 50°C). Again, the exact details depend on the type of LED used. For high power LEDs, operation at maximum brightness may require the use of a heatsink.

The preceding discussion indicates that we can drive a large number of LEDs with even brightness if we have a high supply voltage. Techno is fortunate that the 24V he has available should be sufficient for what he requires.

Often this is not case, with, for example, 3V battery supplies being common. In such cases, therefore, it is necessary to generate a high voltage to drive the LEDs in series, usually with constant current control to set the brightness. There are a number of ICs which perform this function, and one of these, the MAX8596X, was discussed in detail in *Circuit Surgery* in the July '08 issue (pages 60-62).

Switching inductive loads

We now return to the issue of switching inductive loads. When current in an inductive load, such as a relay or solenoid, is switched off, the magnetic field, which had been established by the supplied current, collapses rapidly inducing a reverse voltage known as the *back-EMF* or *inductive kick*. This may result in voltages large enough to damage or destroy the semiconductor devices used to switch the load. The more rapid the change in current as the inductor is switched off, and the larger the inductor value, the greater the back-EMF generated.

The usual method of preventing back-EMF from causing problems is to place a diode (sometimes called the *freewheeling diode*, *flyback diode* or *snubber diode*) across the inductor, as shown in Fig.6. The term *clamped inductive load* is also used in this situation. This diode is reverse biased when the power switching device is on, but is forward biased by the back-EMF; so the diode dissipates the power or feeds it back to the power supply. Obviously, the freewheeling diode must have sufficient switching speed, and power handling capacity, to cope with the energy from the back-EMF.

So, as Echase asks, why do some power MOSFET circuits not depict freewheeling diodes? In power MOSFETs, as in other

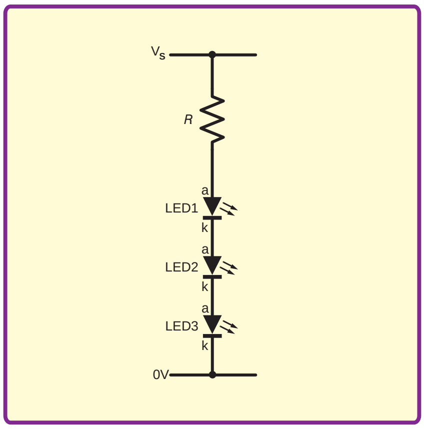

Fig.4. Driving LEDs in series ensures the same forward current, but requires a higher drive voltage.

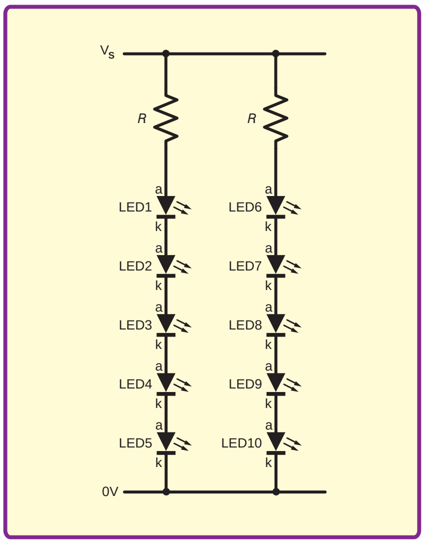

Fig.5. Driving LEDs in series/parallel groups

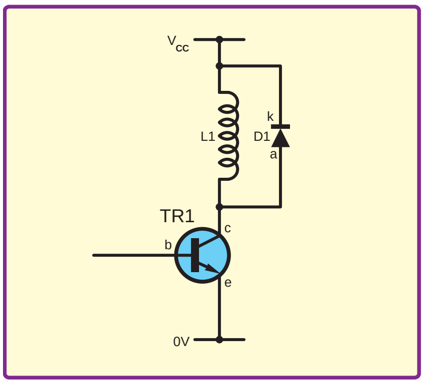

Fig.6. Using a diode to protect a transistor switching an inductive load

semiconductors, the reverse voltage spike from the inductor switching induces avalanche breakdown causing high current flow through the device and therefore high power dissipation, with associated temperature rise, and potential destruction of the device.

Some power MOSFETs are designed to withstand a reasonable amount of avalanche energy and can therefore be used to switch inductive loads, without a protection diode across the load (ie unclamped inductive loads). These devices are often described as *avalanche rugged*, and their capabilities are characterised in terms of their single-shot and repetitive avalanche ruggedness, usually in terms of maximum avalanche energy, or by safe operating area (SOA) curves of maximum avalanche current against time duration

As usual, datasheets should be consulted to determine the suitability of a device to the required application. Manufacturers also publish application notes giving detailed background information on MOSFET avalanche ruggedness. For example AN-1005 from International Rectifier (**www.irf.com**) and AN10273_1 from Philips Semiconductors/NXP (**www.nxp.com**).

Body drain diode

Echase also mentioned the diode which is often depicted between the drain and source on power MOSFET schematic symbols. This is the 'body-drain' or 'parasitic' diode, which is an intrinsic part of the MOSFET's structure. Fig.7 shows power MOSFET symbols that includes these diodes.

The integral body-drain diode in a power MOSFET can sometimes be used as a freewheeling diode when switching inductive loads. The diode conducts when the reverse polarity back-EMF voltage is applied to the device, preventing over-voltage conditions from damaging the MOSFET.

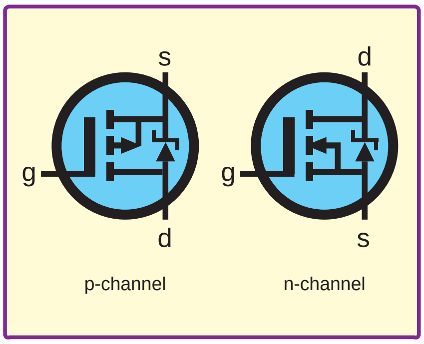

Fig.7. Power MOSFET symbols showing an internal parasitic diode

Power dissipation, for a given current, is higher in 'reverse' conduction via the body-drain diode because the forward voltage drop across the diode is larger than the usual drain to source voltage drop when the device is conducting in the normal way. The device may, therefore, not be able to sustain this condition for long without being destroyed by the heat generated. Hopefully, short-lived inductive kicks will not produce sufficient heat to damage the device.

The current handling capability of the integral body-drain diode is typically as high as that of the transistor itself. However, in applications requiring high frequency switching the intrinsic diode does not have high enough performance and an external diode must be used.

A key problem is that the internal diode does not have a fast enough recovery time; which means it does not switch off fast enough. In some circuits this can lead to short circuit conditions when one MOSFET switches on as another switches off.

Take care when reading power MOSFET schematics to check whether an external high speed diode or the internal body diode is depicted.

Our periodic column for PIC programming enlightenment

Interfacing PICs to the Internet

This month we start on a series of articles that are close to this author's heart – hooking up a microcontroller to the Internet, via an ethernet interface.

The subject is vast and covers a wide range of complex topics. Fortunately, Microchip have made it easy – very easy in fact – to wire up a PIC processor to an ethernet interface, get hooked up to the Internet and explore the possibilities.

Connecting a microprocessor to the Internet opens enormous opportunities, some of which do not become apparent until you start building projects that connect to it. Examples of what you can do with a simple PIC microcontroller connected to the Internet include:

- Checking for email
- Polling a remote sensor
- Remote control of equipment
- Publishing sensor information
- Send messages to your mobile phone
- Decoding Internet radio stations

The list could go on, and new, innovative services are being made available on the Internet at a rapid rate.

Information published on the Internet can be made private, accessible only by password, or publicly available – the choice is yours. By default, access is open and information can be viewed by anyone, so bear that in mind when experimenting.

Internet viruses

It is normal these days to be rather paranoid about connecting a computer to the Internet – computer viruses abound, with new ones reported almost weekly. A PIC processor connected to the Internet is not, fortunately, going to suffer from such problems, as computer viruses are designed to run on PCs only and have no way of 'infecting' a home-grown microcontroller project.

At worst, someone can connect to your device and use it, but they won't be able to corrupt the device and leave a malicious program. Not so with a PC! It's really pot-luck that a PC connected to the Internet does not get infected these days.

So what exactly is ethernet, and how does it relate to the Internet?

ARPANET

Before discussing ethernet, let's take a look at the Internet. The Internet was first conceived at the end of the 1960s as a research project set up by DARPA, a division of the American Department of Defense, to find a way to hook up the various mainframe computers at academic and defence contractor sites across the country. It's an incredible story, too big to give full justice to here. In those days the network was called ARPANET, but it later became the Internet, in recognition of the fact that the system became a 'network of interconnected networks'.

What the designers realised while they were developing the network infrastructure was that a common means of exchanging information between computers was required. Until that point, mainframe computers had their own, manufacturer-specific means of communication. So a computer from ICL could not communicate with one from Honeywell.

To solve this problem the designers developed a protocol for exchanging information, called TCP/IP. In those days the term 'protocol' had never before been used in a computing context, so while it is a common term today in computing it was a novel use of the word then.

In a nutshell, TCP/IP is a set of standards that define how computers connected to each other in a large network can exchange information between themselves reliably. It does not explain or even refer to how the data will be transferred – the electrical connections between the computers – just how connections can be established, maintained, and information exchanged without loss or corruption. The electrical connections were considered to be handled by a 'lower layer' of software below TCP/IP.

Layered approach

This 'layered' approach to software extended to the design of TCP/IP itself. TCP/IP is really two acronyms, TCP standing for 'Transport Control Protocol' and IP standing for 'Internet Protocol'. IP is the layer of software designed to transport data from one computer to another, while TCP is the protocol which provides *reliable* exchange of data. TCP sits on top of IP, and any computer application that wants to exchange information reliably with another computer would call functions within the TCP software library to do it.

TCP/IP provided the lower levels of software to allow computers to connect, but at the time of its inception no software existed to actually *use* it. This was the beginning of network computing and these were ground breaking days – as the engineers involved in the work soon realised.

As more and more computers became connected to the ARPANET, so more computer scientists and engineers were exposed to it, and soon hundreds of skilled programmers started finding new ways to use it. Programs such as *Finger*, *Archie*, *Gopher*, *ftp*, *Telnet* and the ubiquitous *email* were developed to exploit the new frontier of interconnected computers, and some of these programs still persist today (email being the obvious one!)

In those days, the ARPANET was a completely open network – the idea of password protecting a computer from rogue access was unheard of, and largely unnecessary. The computers cooperating in the ARPANET were sited at defence contractors or selected universities, and security was mostly self-policing. It's only as recently as the late 1980s that restrictions on access to services started to become password protected. The idea of an open mainframe computer system would be ridiculous today.

During the early 1980s the ARPANET extended beyond the USA into European universities and beyond. By the middle of the 1980s access into ARPANET (the Internet as it was now being called) came into the reach of ordinary citizens through ISPs – internet service providers.

In those days, ISPs were forward thinking companies who recognised the increasing demand for access to the Internet, and started wiring up large numbers of modems between their corporate Internet access and the public telephone system. Users could dial into the company's telephone system, be connected to a modem and connected onto the Internet. Users' computers were connected to the Internet only while they were dialed into the ISP's modem, which was something one only did for a few hours a day (and usually, annoying the rest of the household!)

Broadband

By the end of the 1990s an alternative to dial-up Internet access became available – broadband. Broadband offered three significant improvements over dial-up access. First, it didn't interfere with your normal voice telephone. Improvements in digital telephone exchange systems meant that the high frequency broadband signals could be carried over the telephone wires at the same time as voice signals, meaning that you no longer annoyed the rest of the household.

Second, data rates jumped significantly from the 56K bits/s available from dial-up to rates over 2M bits/s. Finally, the feature

that is most useful to us, is that broadband services were provided full time – the charge was a flat monthly connection fee, not by the minute that you are connected.

That final point significantly changed the way people used the Internet. The Internet was no longer something that you had to dial into, and wait a few minutes to access while the computers connected to each other. The Internet was there, all the time.

It became a pervasive presence in the house, with information and communication with others available instantly. Broadband access was fast, and did not use a serial link between the modem and the PC – it required something faster, and the main interface technology that came to dominate was Ethernet.

Ethernet

Ethernet is a standard for physical interfaces between computers. It was developed back in the mid 1970s, almost in parallel with the development of the ARPANET. In those days, serial links such as RS232 were the norm, designed to connect devices such as teletype terminals and printers to a computer. These were slow links, running at a few hundreds or thousands of bytes per second.

As the complexity of peripheral devices increased (such as the introduction of colour, graphical terminals) it became apparent that a faster means of connecting multiple devices together was needed. Ethernet became the dominant standard. A fitting coverage of the development of Ethernet is also, sadly, beyond the scope of this article (if you know of a good book on the subject, do let us know!)

Ethernet started as an expensive solution compared to lower speed serial interfaces, but as its usefulness became apparent and adoption increased, prices plummeted. The standard has improved over the years, with interfaces remaining backward compatible with the earlier, slower ones while still using the same physical interface.

These days, computers are shipped by standard with a 100M bits/s or 1G bits/s ethernet interface, which still supports older 10M bits/s devices. As we will see in later articles, this last point is quite important – the ethernet interface devices available from Microchip only support connection to other devices at 10M bits/s.

On the uptake

The exponential increase in the availability and uptake of broadband Internet connections by home users is what makes the subject of this series of articles relevant. It's been possible to create small, relatively low cost microcontroller projects that connect to the Internet for over 15 years – but without easy, full-time access to the Internet there has simply been no point. In the past, you would have needed a computer to dial into the Internet, and you would have needed to connect your microprocessor system to the computer to connect onto the Internet. In practice, the microcontroller would have simply been a peripheral device on the PC.

These days, however, a broadband connection to the Internet is provided by a high speed modem that has several ethernet interfaces free, to allow multiple PCs to be connected. If your microcontroller project has an Ethernet interface you no longer need the PC to be switched on – you simply connect it to the modem, and the world is suddenly at your finger tips!

With today's 'all pervasive' Internet, you also have easy access to your device remotely. You can connect to the Internet from work, in libraries or Internet cafes anywhere in the world. And once connected to the Internet, you can access your device, which may be at home or some other distant location.

Using a small home-built 'Internet enabled' device has additional benefits too. Power consumption is going to be significantly lower than a PC (300 milliwatts rather than the 150 watts of a typical PC), which is a significant consideration in these days of increasing energy costs.

The security issues are much better too – a PC left connected to the Internet is vulnerable to attack from computer viruses and hackers, while a PIC based device will not be. You could implement an Internet enabled sensor monitoring system without having to worry about someone placing rogue software onto your computer that might reveal sensitive personal data.

The Web

Throughout this whistle-stop tour of the history of the Internet we have missed out the most significant development of Internet software. The World Wide Web, invented by British academic Tim Berners-Lee while he was working at CERN in Switzerland, helped transfer the Internet from the domain of the geek to the domain of the general public.

The invention was actually a software protocol – HTTP, or hypertext transfer protocol, which defined a system for exchanging information written in a simple text-based standard, called HTML. HTML defines how you store text, images and crucially links to other sources of information.

Previously, information would have been stored as simple text files, or were binary files that had to be opened by the program associated with that file. Although HTML documents are written as simple text files containing text, links to images and links to other documents, a special program – the web browser – was developed that could present this information in a nicely formatted way.

A web browser is now the defacto means of accessing the Internet, and is installed on every computer that can access the Internet. HTML and HTTP are also well defined standards now, and despite a few minor incompatibilities, any web browser on any operating system on any computer should display the HTML data in the same way.

Gaining access

To access information on the Internet with a web browser requires the computer serving up the information at the other end to run a program called a *web server*. A web server is a program which simply 'serves up' HTML files to a web browser when requested. Web servers can be implemented as very simple programs (HTTP and HTML are after all very simple protocols), which means that implementing one on a small embedded system can be quite straightforward.

What this means is that it can be easy to produce a very elegant looking user interface to your project (perhaps a nicely formatted web page showing the temperature in your workshop) by writing a simple HTML web page and providing a small web server on your embedded system. This can be much easier than producing a crude terminal interface over RS232, especially as web server programs are freely available for use with the PIC processor.

You can probably guess from the way this discussion is going that to connect your PIC project to the Internet requires some new, complex software: TCP/IP, an ethernet driver, a web server and 'web pages' written in HTML. Fortunately for us, Microchip provide all the software required, for free – all we have to worry about is configuring the software, (selecting the parts we require) and writing some simple web pages to present the information. You can completely ignore the complexities of the Internet connection software, build your own system, and then dip into the lower level code at a later date when you feel like it.

Microchip's offering

So what exactly have Microchip created that enables us, the humble hobbyist, to take advantage of the Internet? It's two things really. The first is a simple, low cost, and easy-to-use ethernet interface IC, and the second is the TCP/IP software to drive it.

The significance of the phrase 'easy to use' in that first point cannot be overstated. Ethernet interface ICs have been available for years, but until now they have been too complex for use by the average hobbyist. Initially, an Ethernet interface required several ICs, including special storage memory, and were complicated to access with a simple microcontroller. In more recent years, ICs have been created (such as the Realtek RTL8019) that reduce the component count to a single IC and a few passives.

These devices, however, are only produced in fine pitched packages that are difficult to solder, and have complex processor interfaces. Microchip have solved this problem by introducing a single chip solution that is available in a dual-in-line package with an SPI interface to the processor – which means that an Internet capable project could be constructed easily, cheaply and on stripboard. These parts are also available from many 'hobbyist friendly' suppliers, which means that this really is a practical option, and not just some theoretical solution available only to the few. The cost of the components required to implement an Internet interface can be as low as £10.

Interfacing to the Internet does require some complex software, but with Microchip's help developing an Internet project can now be approached by the interested hobbyist.

In next month's article we will take a deeper look at the TCP/IP protocols, and take a look at the Microchip ethernet interface IC – the ENC28J60.

PICmicro TUTORIALS AND PROGRAMMING

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SOFTWARE

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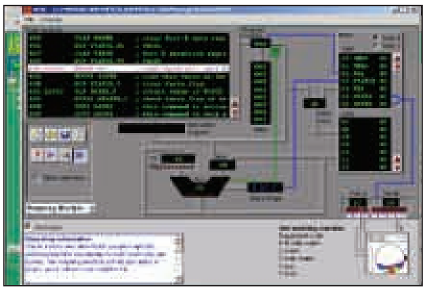
(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes.

The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro micro-controller. this is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed which enhances understanding.

● Comprehensive instruction through 45 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.

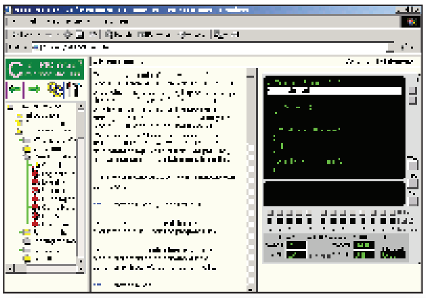


'C' FOR 16 Series PICmicro Version 4

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.



Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.

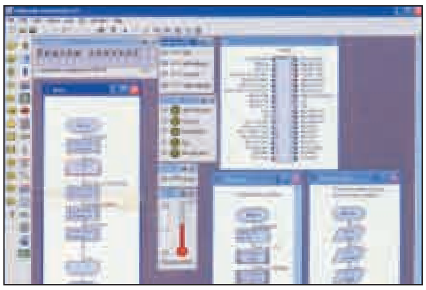
FLOWCODE FOR PICmicro V3

Flowcode is a very high level language programming system for PICmicro microcontrollers based on flowcharts. Flowcode allows you to design and simulate complex systems in a matter of minutes. A Powerful language that uses macros to facilitate the control of devices like 7-segment displays, motor controllers and l.c.d.'s. The use of macros allows you to control these devices without getting bogged down in understanding the programming.

Flowcode produces MPASM code which is compatible with virtually all PICmicro programmers. When used in conjunction with the Version 3 development board this provides a seamless solution that allows you to program chips in minutes.

● Requires no programming experience ● Allows complex PICmicro applications to be designed quickly ● Uses international standard flow chart symbols ● Full on-screen simulation allows debugging and speeds up the development process.

● Facilitates learning via a full suite of demonstration tutorials ● Produces ASM code for a range of 18, 28 and 40-pin devices ● New features in Version 3 include 16-bit arithmetic, strings and string manipulation, improved graphical user interface and printing, support for 18 series devices, pulse width modulation, I2C, new ADC component etc. The Hobbyist/Student version is limited to 4K of code (8K on 18F devices)



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***Flowcode V3** (Hobbyist/Student) – For details on Flowcode, see the previous page.*

This offer gives you two seperate CD-ROMs in DVD style cases – the software will need registering (FREE) with Designsoft (TINA) and Matrix Multimedia (Flowcode), details are given within the packages.

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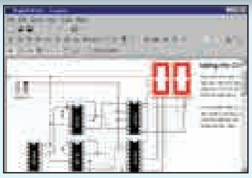

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READOUT

Email: editorial@wimborne.co.uk

John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

All letters quoted here have previously been replied to directly

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★ LETTER OF THE MONTH ★

More on Linux and web security

Dear EPE,

Following up on Graham Harby's June *Letter of the Month*, 'Linux and web security' and Alan's June/July response, I really found this discussion useful with my laptop shackled with half a dozen anti-virus type applications from HiJackThis and Spy Doc to Avast. All consume resources, if not scanning they are busy updating or complaining about the licence expiring, bringing to mind the phrase 'spider to catch the fly'!

Having read Graham's letter explaining about the Linux operating system and how there are no known 'live' Linux viruses, I found the perfect solution for me; use the Linux operating system for surfing the net and Windows for everything else. In his letter, Graham recommended the 'Ubuntu' distribution of Linux because of its ease of use and the fact that it is all absolutely free!

I then followed his advice and installed it in a new partition of my Windows disk drive, so I was able to dual boot (to Windows and Ubuntu). It was easy to install, as long as you follow the installation instructions on the Ubuntu website, and was ready to use in about twenty minutes.

My first impression of Ubuntu is that it is very user friendly and it came with everything from wordprocessing software to vector drawing packages. My parents, who find Windows awkward to use, thought Ubuntu was a breeze in comparison.

The only problem that I encountered was the lack of peripheral compatibility. Basic devices worked with the Ubuntu drivers, eg memory sticks and printers, but any hardware that needs specialised drivers for use with Windows obviously would not work straight away.

The ISP that I am currently with provides a USB modem for connection to the internet. This posed an immediate problem as the drivers were designed only for use with Windows. This is where you do need to be a Linux expert, which unfortunately I wasn't.

However, I found a website that explained how to install my Thomson Speedtouch 330 modem using simple step-by-step instructions (**www.linux-usb.org**) and I managed to get it working after several attempts (main problem was downloaded extractor files being saved as text files, just needed the '.txt' extension removed). Having said this, many people now get their internet through their ethernet port (eg Virgin Media customers), and I understand this connection is fully supported by Linux.

After installing and using Ubuntu myself, I would fully recommend it to anyone (mainstream users and enthusiasts) who want to make sure their computer is safe from hackers, viruses and other spyware without slowing down Windows with memory-consuming security software.

Thanks *EPE*,

James Bickerton, via email

Thanks James, it's good to know of your success and of your recommendation to readers.

PIC N' MIX

Dear EPE,

I would like to comment on the circuit used when multiplexing the 7-segment display, as discussed in *PIC n' Mix*, June '08. For the transistor (will be referred to as upper) which drives the common anode of the display, I would normally prefer a *PNP* type. This helps to ensure an even more consistent driving current for each segment.

The main reason lies in the base-driving voltage of the transistor. A quick check on the datasheet shows that a BC548 has a $V_{ce(sat)}$ of 0.6V at 100mA (I_b at 5mA). Add that to the segment voltage of 2V and the V_{be} of 0.7V, and you will need to drive the upper transistor with at least (0.6V + 2.0V + 0.7V) = 3.3V.

According to the PIC's datasheet, a typical I/O output high minimum voltage is V_{dd} − 0.7V, which is 4.3V. So, you'll have 1.0V of buffer to drop over the 470Ω resistor, which give you I_b of 2.1mA, less that the I_b specified for that $V_{ce(sat)}$. This means you'll actually have a higher $V_{ce(sat)}$ and lower I_c. For a different I_c you'll get a different gain factor, which makes the matter worse. Thus, when different numbers of segment are driven, the $V_{ce(sat)}$, I_b and I_c will fluctuate greatly.

If you use a Darlington transistor instead of the BC548, you'll get less fluctuation due to the much higher current gain. But you'll have less margin to work with as you need to have a minimum driving voltage of 4.0V (V_{be} for Darlingtons is 1.4V). A slight drop in the supply voltage means a blanked display.

If a *PNP* transistor is used instead, you'll get a very consistent $I_b/V_{ce(sat)}$, since the segment current is not involved. I've been using 2N2222/2N5401 and 2N3904/2N3906 to drive 7-segment displays. They all have a $V_{ce(sat)}$ of around 0.3V, which gives me plenty of room to work with.

Sometime, I even use 7407 (Hex open-collector inverter) to replace the *NPN* transistor for a common cathode display, as it saves me some room and a few resistors, it can also be easily hooked to a latch in case I run out of I/O.

Lee Faulty, via email

Thanks Lee, you might care to read last month's Circuit Surgery *as it covers similar matters.*

Schematic software

Dear EPE,

I have read Steve Liggett's letter, January 2008, about circuit diagram software. For several years I have been using a freeware program called TinyCAD. Its schematics are not as nice as those in *EPE*, but are better than those from most schematic software.

It can be downloaded from **tinycad.sourceforge.net** and was written by Matt Pyne of Milton Keynes. There is a good set of symbols included. Symbols may not always be consistent, as several were contributed by users, including myself, but you can usually find a useable one. It is also rather easy to draw new symbols and add them to the library.

Bill Stiles, Hillsboro, MO, USA, via email

That could be useful to readers Bill, thanks

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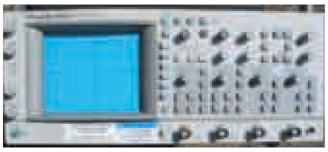

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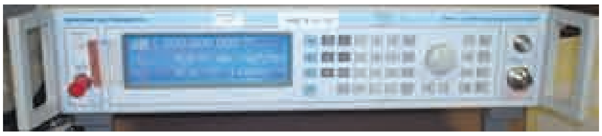

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Net Work

Alan Winstanley

Spare a thought

This month's *Net Work* includes some practical pointers to help Internet users diagnose basic problems with their connection. A number of general hints will also be described to assist in troubleshooting and analysing various aspects of Internet usage.

In order to understand some Internet fundamentals, it helps to familiarise oneself with some basic aspects of Internet connectivity. At the root of the entire Internet is TCP/IP, or Transmission Control Protocol/Internet Protocol (IP), which was created to enable separate computer networks to communicate with each other.

Every resource or 'node' connected to the Internet has its own unique numerical IP address, such as 38.12.34.567. Due to the pressure for 'spare' numbers under the current standard (IPv4), temporary or dynamic IP addressees are often allocated to users each time they connect to the Internet. Other resources, such as web and mail servers need a fixed IP address if the Internet is to hang together properly. Fixed IP addresses are useful in some Internet applications, including virtual private networks or IP security camera networks, when it is desirable that the IP address does not constantly change. The release of IPv6 is some years away, and will allow for better scalability of IP addresses that cannot be achieved under IPv4.

The job of the 'domain name system' (DNS) is to translate or 'resolve' human-recognisable plain English addresses into numerical IP addresses, rather like a telephone directory yields telephone numbers to its readers. Each ISP maintains its own copy of this 'DNS telephone book' as up to date as possible, so that they instantaneously know the correct place to go when you request a web page, email connection or other service.

One way of seeing this DNS translation in action is with some basic software tools, including the Unix or DOS-based network commands built into eg Windows XP. Some very useful online tools are also available that do the same thing, but raw command line tests are fast and need no foible-filled web browser or other complication to use them.

In Windows XP you can open a DOS box by clicking *Start/Run/cmd* (for command prompt). You could drag a shortcut to the Start menu or Quick Launch bar, so you can open a DOS box with a single mouse click.

The first useful command is *Traceroute*, which lists the route from your local node, through the Internet to a remote system. You can use traceroute to help locate servers (and their ISPs) or to test whether they are reachable, or see if part of the route is slow or broken. For example, at the DOS command prompt type:

>tracert www.epemag.wimborne.co.uk

Hop to it

The process of 'hopping' from your own IP address through to that of the remote host then begins, in this case aiming for the web server that hosts our own website. Immediately, the IP address [195.80.2.3] of the website's server is revealed by a DNS translation (see screenshot). If the IP address is shown when you hit 'return', then you know that your system is reaching out onto the Internet properly and that your ISP's DNS servers are functioning, otherwise the DNS lookup could not happen.

If this DNS/IP address translation does not happen at all, then there is probably a fault at your end of the network, possibly with your Internet connection, or (very rarely) an outage with your own ISP's DNS servers. You should first try unplugging your router for several minutes, before starting again with a traceroute; check that all network and router cables are inserted properly, and if in doubt eliminate any extension leads or inline suppressor faults from the equation by plugging your router directly into the ADSL splitter. Connectivity faults are regularly due to mechanical reasons that can soon be repaired. Check the router LEDs too. If no connection is available then allow say 20 to 30 minutes before calling your ISP.

If all is well with the tracert session then the path through to our own host (TCP is our UK-based ISP) will be listed, one hop at a time. Try a tracert on **www.ebay.co.uk** to see how it hops to the USA. You can pick any other host (your POP3 mail server for instance) to tracert as required.

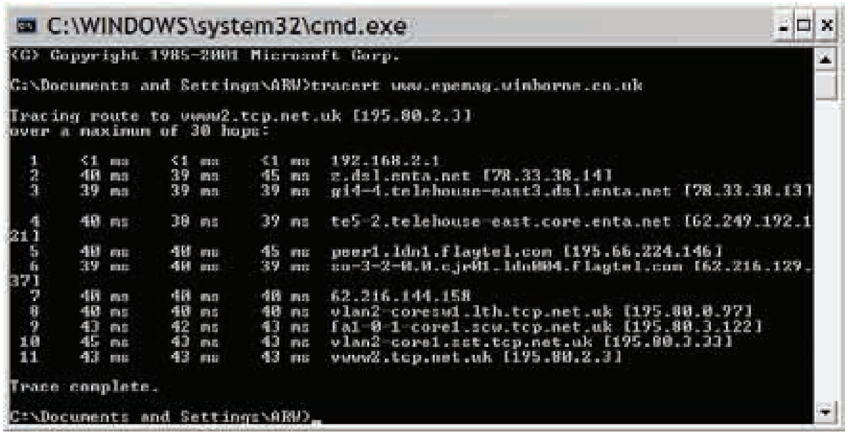
Note how your own IP address is also shown, starting with the 'local' IP address of your PC [192.168.2.1], before reaching out onto the Internet where an IP address of 78.33.38.14 is shown in this example.

Chicken run

A useful aspect to remember about a broadband router is that you may run multiple PCs on a local area network, each of which adopts a unique 'local' IP address that is masked from the outside world. Other machines on my LAN have unique addresses such as 192.168.2.2 or 192.168.2.8 and so on.

The router, however, has a unique IP address that is visible, which is allocated by the internet service provider. It is the job of a router to channel Internet traffic (web, email, FTP etc) from the outside world through to the appropriate machine residing behind the router. A personal favourite website that reveals your IP address is IP Chicken (**www.ipchicken.com**). A nice graphical tracert service is available at **http://visualroute.visualware.com/**

Traceroute is therefore handy for general web and broadband debugging. If the remote host is unreachable along the way, then any server or network-related problem can be difficult to rectify, and by the time they have been highlighted, problems have often cured themselves anyway.



Screenshot of a typical session from the Windows XP command prompt

In next month's *Net Work* I'll continue on the same theme, outlining more useful software tools and commands, together with practical examples of their application. You can email Alan at: **alan@epemag.demon.co.uk**

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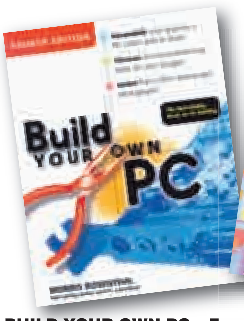

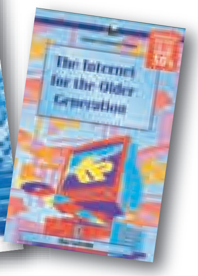

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Lucio Di Jasio (Application Segments Manager, Microchip, USA)

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Clive (Max) Maxfield

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This book gives the 'big picture' of digital electronics. This in-depth, highly readable, guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more. The author's tongue-in-cheek humour makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. Comes with a free CD-ROM which contains an eBook version with full text search plus bonus chapter – An Illustrated History of Electronics and Computing.

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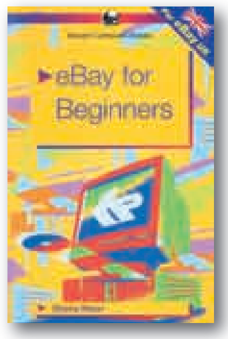

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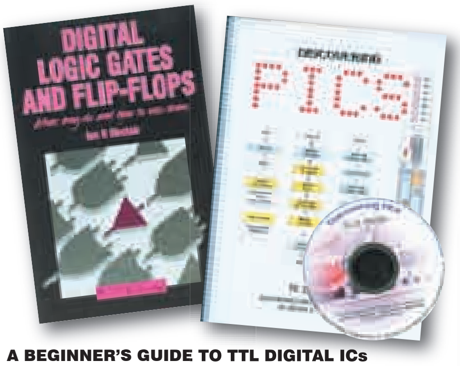

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Published on approximately the second Thursday of each month by Wimborne Publishing Ltd., Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU. Printed in England by Apple Web Offset Ltd., Warrington, WA1 4RW. Distributed by Seymour, 86 Newman St., London W1T 3EX. Subscriptions INLAND: £19.95 (6 months); £37.90 (12 months); £70.50 (2 years). OVERSEAS: standard air service, £23.00 (6 months); £44.00 (12 months); £83.00 (2 years). Express airmail, £32.00 (6 months); £62.00 (12 months); £119.00 (2 years). Payments payable to "Everyday Practical Electronics", Subs Dept, Wimborne Publishing Ltd. Email: subs@epemag.wimborne.co.uk. EVERYDAY PRACTICAL ELECTRONICS is sold subject to the following conditions, namely that it shall not, without the written consent of the Publishers first having been given, be lent, resold, hired out or otherwise disposed of by way of Trade at more than the recommended selling price shown on the cover, and that it shall not be lent, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.

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